AR TARGET SHEET

The following document was too large to scan as one unit, therefore, it has been divided into sections.

EDMC#:	0074012
SECTION:	1 OF 2
DOCUMENT #:	07-AMCP-0294
TITLE:	Feasibility Study for 200-CS-1 Chemical Sewer Group OU DOE/RL-2005-63 Draft B Reissue and Proposed Plan for 200-CS-1 Chemical Sewer Group OU DOE/RL-2005-64 Draft B Reissue

0074012

Department of Energy

Richland Operations Office
P.O. Box 550
Richland, Washington 99352

SEP 27 2007

07-AMCP-0294

Ms. J. A. Hedges, Program Manager
Nuclear Waste Program
State of Washington
Department of Ecology
3100 Port of Benton
Richland, Washington 99352

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EDMC

Dear Ms. Hedges:

FEASIBILITY STUDY FOR THE 200-CS-1 CHEMICAL SEWER GROUP OPERABLE UNIT, DOE/RL-2005-63, DRAFT B, REISSUE, AND PROPOSED PLAN FOR THE 200-CS-1 CHEMICAL SEWER GROUP OPERABLE UNIT, DOE/RL-2005-64, DRAFT B, REISSUE

References: (1) RL ltr. to J. A. Hedges, Ecology, from M. S. McCormick, "Comment Response for the Feasibility Study for 200-CS-1 Chemical Sewer Group Operable Unit, DOE/RL-2005-63, Draft A," (07-AMCP-0084), dtd. February 2, 2007. 0072094

(2) RL ltr. to J. A. Hedges, Ecology, from K. A. Klein, "Plan for Revision of Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit, DOE/RL-2005-63, Draft A and Proposed Plan for the 200-CS-1 Chemical Sewer Operable Unit, DOE/RL-2005-64, Draft A," (06-AMCP-0278), dtd. August 31, 2006. 0070763

(3) Ecology ltr. to L. D. Romine, RL, from J. B. Price, "DOE Letter 06-AMCP-0254, Compliance with Interim Milestone M-015-39C for 200-CS-1 Operable Unit Feasibility Study," dtd. July 31, 2006. 0070289

The purpose of this letter is to transmit the Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit, DOE/RL-2005-63, Draft B, Reissue, and Proposed Plan for the 200-CS-1 Chemical Sewer Group Operable Unit, DOE/RL-2005-64, Draft B, Reissue for your review and approval. These documents complete the Document Update Plan in Reference (2) per Tri-Party Agreement Action Plan Section 9.2.1, and Reference (3). As Draft B documents, the State of Washington Department of Ecology (Ecology) has 30 days following receipt, to provide a response.

Both documents were prepared consistent with the comment response in Reference (1) and the February 20, 2007, workshop with the U.S. Department of Energy, Richland Operations Office (RL) and Ecology. The workshop presented the path forward for the development of the feasibility study, the proposed plan, and concluded the comment response feedback.

RL acknowledges that Ecology has formally stated that it does not plan to implement a Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) record of decision as the decision document for this operable unit. Instead, Ecology will prepare a draft Resource Conservation and Recovery Act (RCRA) Permit modification for closure of the three treatment, storage, and/or disposal units (TSDs) and integrate RCRA corrective action for the non-TSD waste site (216-S-11) with the 216-S-10 Pond and Ditch TSD.

RL has legal requirements that are not met by Ecology's proposed regulatory pathway. DOE, as a CERCLA lead agency, is required to complete a decision process that addresses both radionuclide contaminants as well as the chemical contaminants. RL is also required by law to comply with DOE's National and Environmental Policy Act Implementing Procedures (10 Code of Federal Regulations 1021). RL is agreeable to further discussions with Ecology about regulatory solutions that allow the Tri-Parties to meet their legal obligations.

Ecology's July 3, 2006, letter that transmitted comments on the 200-CS-1 FS stated that, "Ecology will review and comment on those closure plans after the USDOE revises and re-submits the FS." Therefore, RL would expect review and comments on the three closure/post-closure plans within 90 days of receipt of this letter consistent with Tri-Party Agreement Action Plan Section 9.2.2, Part B Permit Applications and Closure/Post-Closure Plans, and Figure 9-2, Part B Application and Closure/Post-Closure Plan Process Flowchart. RL will plan to begin updating the closure plans within 30 days after receiving Ecology's comments on the Draft B revisions of the feasibility study and proposed plan.

If you have any questions, please contact me, or your staff may contact Matt McCormick, Assistant Manager for the Central Plateau, on (509) 373-9971.

Sincerely,

David A. Brockman
Manager

AMCP:BLF

Attachments

cc: See Page 3

cc w/attach:
N. Ceto, EPA
S. L. Leckband, HAB
J. B. Price, Ecology
Administrative Record 200-CS-1
Environmental Portal

cc w/o attach:
B. A. Austin, FHI
G. Bohnee, NPT
R. C. Brunke, FHI
L. Buck, Wanapam
C. E. Cameron, EPA
R. H. Engelmann, EFSH
S. Harris, CTUIR
Z. Jackson, Ecology
R. Jim, YN
K. Niles, ODOE
R. E. Piippo, FHI
J. G. Vance, FFS
J. A. Winterhalder, EFSH

DOE/RL-2005-63
DRAFT B - REISSUE

Feasibility Study for the 200-CS-1 Chemical Sewer Group Operable Unit

Date Published
September 2007

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States Department of Energy
P.O. Box 550
Richland, Washington 99352

Release Approval 09/14/2007
Date

CONTENTS

APPENDICES

FIGURES

TABLES

TERMS

ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BAF	bioaccumulation factor
BCG	biota concentration guide (see DOE-STD-1153-2002)
bgs	below ground surface
BRA	Bonneville Power Administration
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CLARC	cleanup levels and risk calculations
COC	contaminant of concern
COEC	contaminant of ecological concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CUL	cleanup level
DOE	U.S. Department of Energy
DQO	data quality objective
Ecology	Washington State Department of Ecology
EF	exceedance factor
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ET	evapotranspiration
FS	feasibility study
HEIS	*Hanford Environmental Information System* database
IC	institutional control
Implementation Plan	*200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE/RL-98-28)
IRIS	*Integrated Risk Information System*
LOAEL	lowest observed adverse-effect level
NEPA	*National Environmental Policy Act of 1969*
NMLS	Neutron-Moisture Logging System
NOAEL	no observed adverse-effect level
NPL	"National Priorities List" (40 CFR 300, Appendix B)
ORNL	Oak Ridge National Laboratory
OU	operable unit
PAH	polyaromatic hydrocarbon
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction (Plant or process)
QA/QC	quality assurance/quality control
RAO	remedial-action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR/RAWP	remedial design report/remedial action work plan
REDOX	Reduction-Oxidation (Plant or process)

RESRAD	RESidual RADioactivity (dose model)
RI	remedial investigation
RIRFAT	remedial investigation report, full appendix tables
RIRSAT	remedial investigation report, summary appendix tables
RL	U.S. Department of Energy, Richland Operations Office
RME	reasonable maximum exposure
ROD	record of decision
SGLS	Spectral Gamma-Ray Logging System
SLERA	screening-level ecological risk assessment
Tri-Parties	DOE, EPA, and Ecology
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
TSD	treatment, storage, and/or disposal (unit)
WIDS	*Waste Information Data System* database
Work Plan	*200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan* (DOE/RL-99-44)

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If you know	*Multiply by*	*To get*	*If you know*	*Multiply by*	*To get*
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0394	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles (statute)	1.609	kilometers	kilometers	0.621	miles (statute)
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.0929	sq. meters	sq. meters	10.764	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.591	sq. kilometers	sq. kilometers	0.386	sq. miles
acres	0.405	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces (avoir)	28.349	grams	grams	0.0353	ounces (avoir)
pounds	0.454	kilograms	kilograms	2.205	pounds (avoir)
tons (short)	0.907	ton (metric)	ton (metric)	1.102	tons (short)
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.034	ounces (U.S., liquid)
tablespoons	15	milliliters	liters	2.113	pints
ounces (U.S., liquid)	29.573	milliliters	liters	1.057	quarts (U.S., liquid)
cups	0.24	liters	liters	0.264	gallons (U.S., liquid)
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts (U.S., liquid)	0.946	liters	cubic meters	1.308	cubic yards
gallons (U.S., liquid)	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
Temperature			**Temperature**		
Fahrenheit	(°F-32)*5/9	Centigrade	Centigrade	(°C*9/5)+32	Fahrenheit
Radioactivity			**Radioactivity**		
picocurie	37	millibecquerel	millibecquerel	0.027	picocurie

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1.0 INTRODUCTION

The Hanford Site, managed by the U.S. Department of Energy (DOE), encompasses approximately 1,517 km^2 (586 mi^2) in the Columbia Basin of south-central Washington State. In 1989, the U.S. Environmental Protection Agency (EPA) placed the 100, 200, 300, and 1100 Areas of the Hanford Site on the National Priorities List (NPL) (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List") pursuant to the *Comprehensive Response, Compensation, and Liability Act of 1980* (CERCLA), also known as Superfund. The 200 Areas NPL site consists of the 200 West Area and the 200 East Area, as seen in Figure 1-1, which contain waste management facilities and inactive irradiated fuel reprocessing facilities, and the 200 North Area, formerly used for interim storage and staging of irradiated fuel. Several waste sites in the 600 Area, which are located near the 200 Areas, also are included in the 200 Areas NPL site. The 200 Areas consists of approximately 850 waste sites organized into 24 waste site groups, called operable units (OU). The 200-CS-1 Chemical Sewer Group OU (200-CS-1 OU) is the focus of this feasibility study (FS).

The Superfund program establishes the remedial investigation (RI) and FS as the methodology for "...characterizing the nature and extent of risks posed by uncontrolled hazardous waste sites and for developing and evaluating remedial options" (EPA/540/1-89/002, *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A) (Interim Final)*). The RI/FS methodology is an analytical process intended to support risk management decision making for Superfund sites by assessing risk to human health and the environment. The process for characterization and remediation of waste sites at the Hanford Site is addressed in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989, as amended). This agreement addresses the integration of cleanup programs under CERCLA and the *Resource Conservation and Recovery Act of 1976* (RCRA) to provide a standard approach to directing cleanup activities in a consistent manner and to ensure that applicable regulatory requirements are met. Details of the 200 Areas integration are presented in DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, hereafter referred to as the Implementation Plan. In 2002, the Tri-Parties, which includes the DOE Richland Operations Office (RL), the EPA, and the Washington State Department of Ecology (Ecology) renegotiated the 200 Areas cleanup milestones under the Tri-Party Agreement; the results of these negotiations are documented in Tri-Party Agreement change forms M-13-02-01, M-15-02-01, M-16-02-01, and M-20-02-01.

The 200-CS-1 OU consists of five waste sites. The waste unit designations and their aliases are as follows:

- 216-A-29 Ditch, Snow's Canyon, Plutonium-Uranium Extraction (PUREX) Plant Chemical Sewer
- 216-B-63 Trench, B Plant Chemical Sewer

- 216-S-10 Ditch, 202 Chemical Sump #1 and Ditch, Chemical Sewer Trench, Open Ditch to the Chemical Sewer Trench
- 216-S-10 Pond, 202 Chemical Sump #1 and Ditch, Chemical Sewer Trench
- 216-S-11 Pond, 202-S Chemical Sump #2, Chemical Sewer Trenches, 216-S-11 Swamp.

The waste sites are contained in two areas shown in Figures 1-2 and 1-3. The 200-CS-1 OU waste sites are primarily artificial surface ponds, ditches, or trenches, and were created to dispose of the chemical sewer discharges from the separation/concentration processes (e.g., those at the PUREX Plant and the Reduction-Oxidation [REDOX] Plant, and the B Plant cesium/strontium recovery operations). Early chemical sewer wastes were combined with larger cooling-water and steam-condensate streams from the bismuth-phosphate and uranium-recovery processes and were discharged to ponds and ditches. Operating records for the 200-CS-1 OU waste sites do not contain sufficient detail to determine radionuclide and chemical inventories. However, historical data suggest that the discharges most likely contained dilute discharges of inorganic and/or organic chemicals. Radionuclide inventories are very small to negligible, although uranium is present at several sites, particularly the 216-S-10 Ditch, which received an estimated 215 kg of uranium in an unplanned release. The process history for the 200-CS-1 OU waste sites is described in detail in DOE/RL-99-44, *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan*, hereinafter referred to as the Work Plan. A summary of the 200-CS-1 OU waste site process histories is provided in Section 2.3 of this FS.

1.1 REMEDIAL INVESTIGATION AND OTHER KEY ACTIVITIES

Information regarding land use, points of compliance, remedial-action objectives (RAO), and institutional controls (IC) is important to understanding the basis for the risk assessments and remedial alternative evaluations presented in this FS. The current and foreseeable future land-use designations for the 200 Areas are industrial-exclusive and industrial, respectively. The industrial designation encompasses the 200 Areas, waste management facilities adjacent to the 200 Areas, and peripheral waste sites such as the S Ponds and B Pond. As a result, the industrial land-use scenario will be used for the 200 Areas risk assessments and the establishment of threshold cleanup levels (CUL). For waste sites in the 200 Areas with contaminated soil, the point of compliance for direct contact by human and ecological receptors is the top 4.6 m (15 ft) of soil, and the entire vadose zone (0 m to groundwater) is considered for the protection of groundwater. Both the regulators and DOE agreed that a consistent set of RAOs be developed and used for CERCLA-related activities; these were established and documented in the Implementation Plan (DOE/RL-98-28). ICs will supplement technically feasible remediation alternatives but will not be the primary remedial action unless other alternatives are impractical. DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions*, describes ICs that commonly are included in CERCLA response actions at the Hanford Site.

Documentation of the activities preceding this FS (i.e., project scoping activities such as site history reviews, land-use characterization, work plans, and preliminary remediation goals [PRG]) has occurred in a number of reports discussed below. Table 1-1 summarizes the history of these key activities that form the basis for the work presented in this FS.

The Work Plan (DOE/RL-99-44) documents the background and rationale, as well as detailed plans, for the conduct of RI/FS activities for the 200-CS-1 OU waste sites. RI sampling activities were conducted from November 1999 to April 2003, in accordance with the Work Plan (DOE/RL-99-44), and reported in DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*, hereafter referred to as the RI Report. The purpose of the RI was to determine if data of sufficient quality and quantity have been collected to support risk assessment and remedial decision making; to estimate risks at the representative sites based on the data collected during the RI and other studies; to determine the need to proceed with an FS; and to determine those constituents and site-specific considerations that need to be addressed in the FS.

Four of the five waste sites sampled for the RI are considered representative waste sites:

- 216-A-29 Ditch
- 216-B-63 Trench
- 216-S-10 Ditch
- 216-S-10 Pond.

The fifth waste site, 216-S-11 Pond, is considered an analogous waste site to the 216-S-10 Pond and is assumed to have the same outcome as the 216-S-10 Pond. The rationale for the representative and analogous waste-site approach to characterizing OUs at the Hanford Site is summarized in Section 2.2 and described in more detail in DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations*, and in the Implementation Plan (DOE/RL-98-28).

The RI Report (DOE/RL-2004-17) concluded that the data collected were of sufficient quantity and quality to support the risk-assessment activities and to proceed to the FS to support evaluation of remedial alternatives and identify preferred remedial actions. A human-health and ecological baseline risk assessment was completed as one of the objectives of the RI. Additionally, an evaluation of the groundwater protection pathway was completed and indicated that contaminants currently in the vadose zone likely will impact groundwater in the future, although the RI Report concluded that contaminants are not expected to increase groundwater concentrations above current levels.

The RI sampling strategy focused on potential groundwater impacts and was designed to support a qualitative risk assessment. The sampling was intended to identify worst case/maximum-concentration conditions and is considered a satisfactory approach to complete the RI/FS process and support remedial alternative selection. The sampling strategy was developed with an understanding that additional waste-site sampling would be performed during the remedial design/remedial-action phase to better define the nature and extent of contamination and support refinement of the remedial-action design. Concurrent with the development of the 200-CS-1 OU FS, the Tri-Parties conducted a supplemental data quality objectives (DQO) process for waste sites on the Central Plateau that resulted in Tri-Party

Agreement Change Package M-15-06-02 and in DOE/RL-2007-02, *Supplemental Remedial Investigation/Feasibility Study Work Plan for the 200 Areas Central Plateau Operable Units,* Draft A Volumes I & II. This process and the resulting Tri-Party agreements did not require supplementary RI sampling for the waste sites in the 200-CS-1 OU.

Additionally, during development of this FS, the qualitative nature of the RI sampling strategy and resulting biases and uncertainties related to understanding the nature and extent of contamination associated with the 200-CS-1 OU waste sites were considered a satisfactory approach to complete the RI/FS process and support remedial alternative selection. These biases and uncertainties, in turn, create biases and uncertainties in the conceptual site models and risk-assessment results used for consideration during evaluation of potential remedial response actions in the FS. As a result, understanding the 200-CS-1 OU waste-site sampling strategy described in the Work Plan (DOE/RL-99-44) and the implications of the biases and uncertainties is important when evaluating remedial-action alternatives and devising post-record of decision (ROD) strategies to achieve a safe, effective, and efficient remedy.

Considering these factors, DOE decided to revise the baseline risk assessment (BRA) to reflect the inherent biases and uncertainties and to review and regenerate the analytical data used to support the BRA. The revised BRA presented in this FS provides the basis for the FS.

1.2 FEASIBILITY STUDY PURPOSE

The purpose of this FS is to revise and refine the BRA presented in the RI Report (DOE/RL-2004-17) and document the identification and evaluation of the 200-CS-1 OU waste-site remedial-action alternatives. This FS will refine the RAOs and general response actions initially identified in the Implementation Plan (DOE/RL-98-28). Technology screening and development of remedial alternatives initially performed in the Implementation Plan will be reviewed and refined, as necessary, based on the site-specific data generated in the 200-CS-1 OU RI and other sources of existing information. The alternatives considered provide a range of potential response actions (e.g., no action, remove and dispose, containment) that are appropriate to address site-specific risk conditions. The alternatives will be evaluated against seven of the nine CERCLA criteria (EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (Interim Final)*). The Tri-Parties will use this FS as the basis for selecting a remedy to mitigate potential risks to human health and the environment.

Consequent to this FS, a preferred remedial alternative (or alternatives) will be presented to the public in a proposed plan for review and comment. This FS will support the development of the proposed plan and subsequent ROD. The future remedial design report/remedial-action work plan (RDR/RAWP) will be prepared following the ROD for these waste sites and will provide additional details to support the remediation of the 200-CS-1 OU.

1.3 SCOPE

The scope of this FS follows EPA guidance outlined in EPA/540/G-89/004 and meets the CERCLA requirements. This FS develops and evaluates remedial-action alternatives for cleanup of the 216-A-29 Ditch, the 216-B-63 Trench, the 216-S-10 Ditch and Pond, and the 216-S-11 Pond. Cleanup of these waste sites is designated as a source-control action requiring implementation of remedial actions necessary to prevent the continued release of hazardous substances or contaminants to the environment. The remedial actions proposed for cleanup must be protective of human health and the environment, including protection of ecological receptors, groundwater, and surface waters. While this FS will consider remedial-action alternatives to prevent or mitigate further migration of contaminants from the waste-site sources to groundwater, it does not address remediation of the groundwater beneath the waste sites. Remediation of contaminated groundwater beneath the Central Plateau is the subject of the RI/FS activities under way for the 200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1 Groundwater OUs.

RCRA treatment, storage, and disposal (TSD) closure strategies for the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and 216-S-10 Pond already have been documented in RCRA closure plans and submitted under separate cover. Although these closure plans are not within the scope of this FS, the results of the revised risk assessments and evaluation of remedial-action alternatives may be cause for modifications to the closure plans.

1.4 REPORT ORGANIZATION

The essential elements of the FS process are presented in Chapters 1.0 through 9.0, followed by the references and eight appendices, and are summarized as follows.

- Chapter 1.0 presents the purpose and scope of the FS, summary of key events preceding the FS, and this overview of the report organization.
- Chapter 2.0 presents background information including an overview of the OU, operational histories, descriptions of the waste sites, physical setting, and natural resources, and summarizes the representative and analogous waste sites.
- Chapter 3.0 discusses the BRA completed for the RI and presents the revised BRA. Three risk assessments are completed following EPA and *Washington Administrative Code* guidance: human health, ecological, and groundwater protection pathway. The uncertainties associated with these risk assessments and the implications for the FS are discussed.
- Chapter 4.0 discusses land-use assumptions and develops the overall remedial action objectives and media-specific goals for the waste sites including volumes of contaminated media for each waste site in the 200-CS-1 OU.
- Chapter 5.0 refines the remedial actions identified for the 200 Area waste sites in the Implementation Plan (DOE/RL-98-28). Refining considerations include effectiveness

(likelihood of meeting RAOs for the specific contaminants present at the site), implementability relative to specific site conditions, status of technology development, and relative cost. Remedial alternatives were considered with respect to the effectiveness, implementability, and relative cost.

- Chapter 6.0 describes the remedial-alternative development process, initially conducted as part of the Implementation Plan (DOE/RL-98-28) development, and uses that information in concert with the risk-assessment results to develop the remedial alternatives to be carried forward for detailed and comparative analyses.

- Chapter 7.0 presents a detailed analysis of each of the four remedial alternatives against seven of the nine CERCLA evaluation criteria defined in EPA/540/G-89/004. Of these nine CERCLA evaluation criteria, seven are alternative bounding criteria (protection of human health and the environment; regulatory compliance; long-term effectiveness; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost) and two deal with the public comment process. These two criteria will not be used in this FS. This section also assesses each alternative relative to the *National Environmental Policy Act of 1969* (NEPA) values, as required by DOE.

- Chapter 8.0 presents a comparative analysis of the four remedial alternatives and identifies their relative advantages and disadvantages, based on the seven alternative bounding CERCLA evaluation criteria. The results of this analysis provide a basis for selecting a remedial alternative for each representative waste site and its analogous waste sites.

- Chapter 9.0 summarizes the conclusions of the FS and presents the path forward for remediation of the 200-CS-1 OU waste sites.

- Chapter 10.0 contains all references for the main body of the report. Each appendix contains its own reference section.

- Appendix A presents the raw data used for the revised BRA as remedial investigation report full appendix tables (RIRFAT). Ecology formally requested that the analytical data tables originally presented in the RI Report (DOE/RL-2004-17), Rev. 0, be reformatted and included with this FS.

- Appendix B presents three risk-assessment scenarios to provide information on additional risk scenarios, including the rural-residential, intruder, and Tribal land-use exposure scenarios.

- Appendix C summarizes the data by waste site as remedial investigation report summary appendix tables (RIRSAT). Ecology formally requested that the data summary tables originally presented in the RI Report (DOE/RL-2004-17), Rev. 0, be reformatted and presented in this FS.

- Appendix D summarizes the human-health toxicological profiles for nonradionuclides.

- Appendix E describes the RESidual RADioactivity (RESRAD) modeling completed for the human-health radionuclide risk characterization and the groundwater-protection pathway evaluation.
- Appendix F documents the online cleanup levels and risk calculations (CLARC) database, downloaded on February 6, 2007, used for calculating WAC 173-340, "Model Toxics Control Act -- Cleanup," CULs.
- Appendix G presents an analysis of potential regulatory applicable or relevant and appropriate requirements (ARAR) and available guidance with respect to the 200-CS-1 OU.
- Appendix H presents the basis for the comparative cost estimates. Detailed cost estimates, including applicable alternatives and derived costs for analogous sites, are provided for each representative waste site.

Figure 1-1. Location of the Hanford Site and the 200-CS-1 Operable Unit Waste Sites.

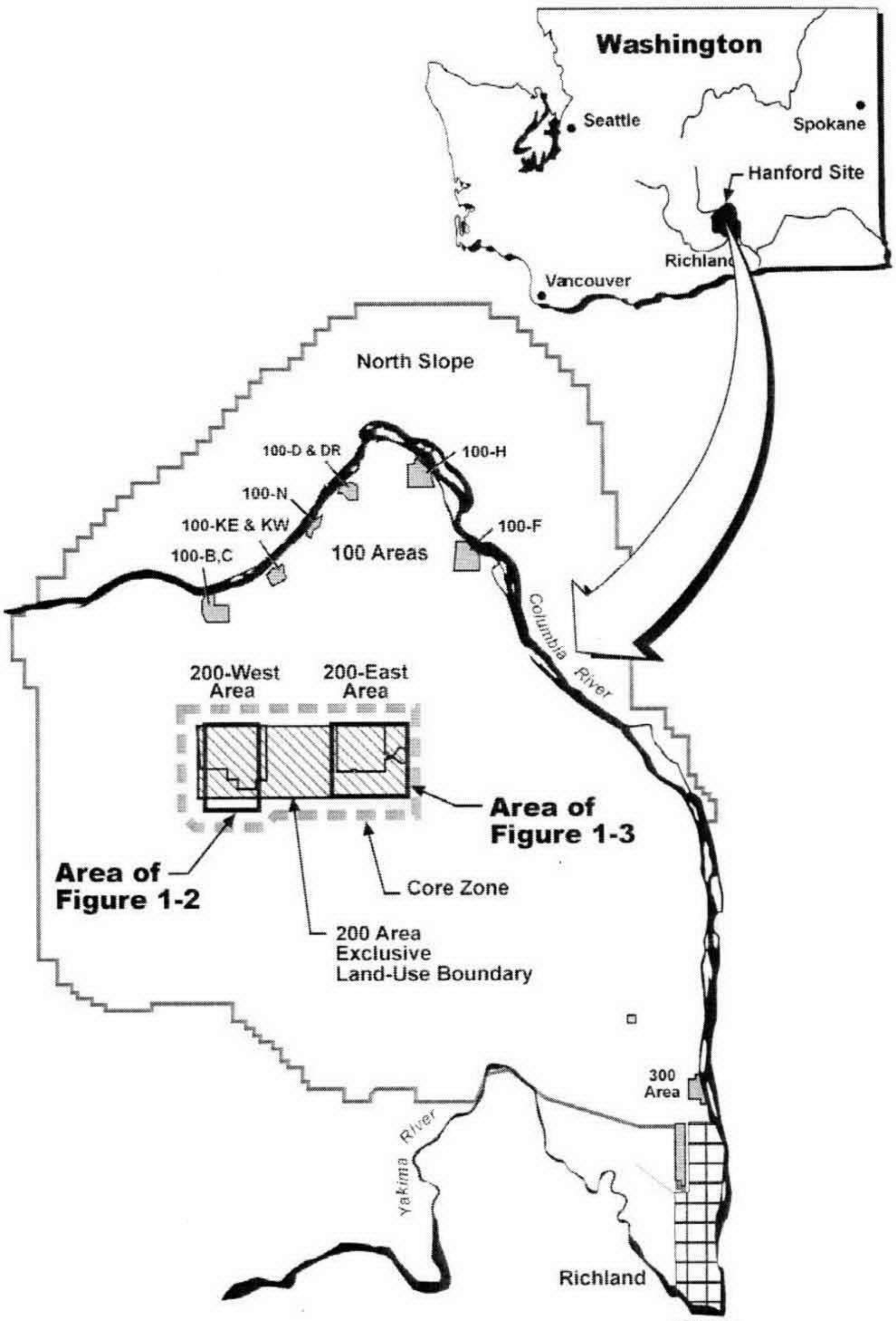


Figure 1-2. Location of the 200-CS-1 Operable Unit Waste Sites in the 200 West Area.

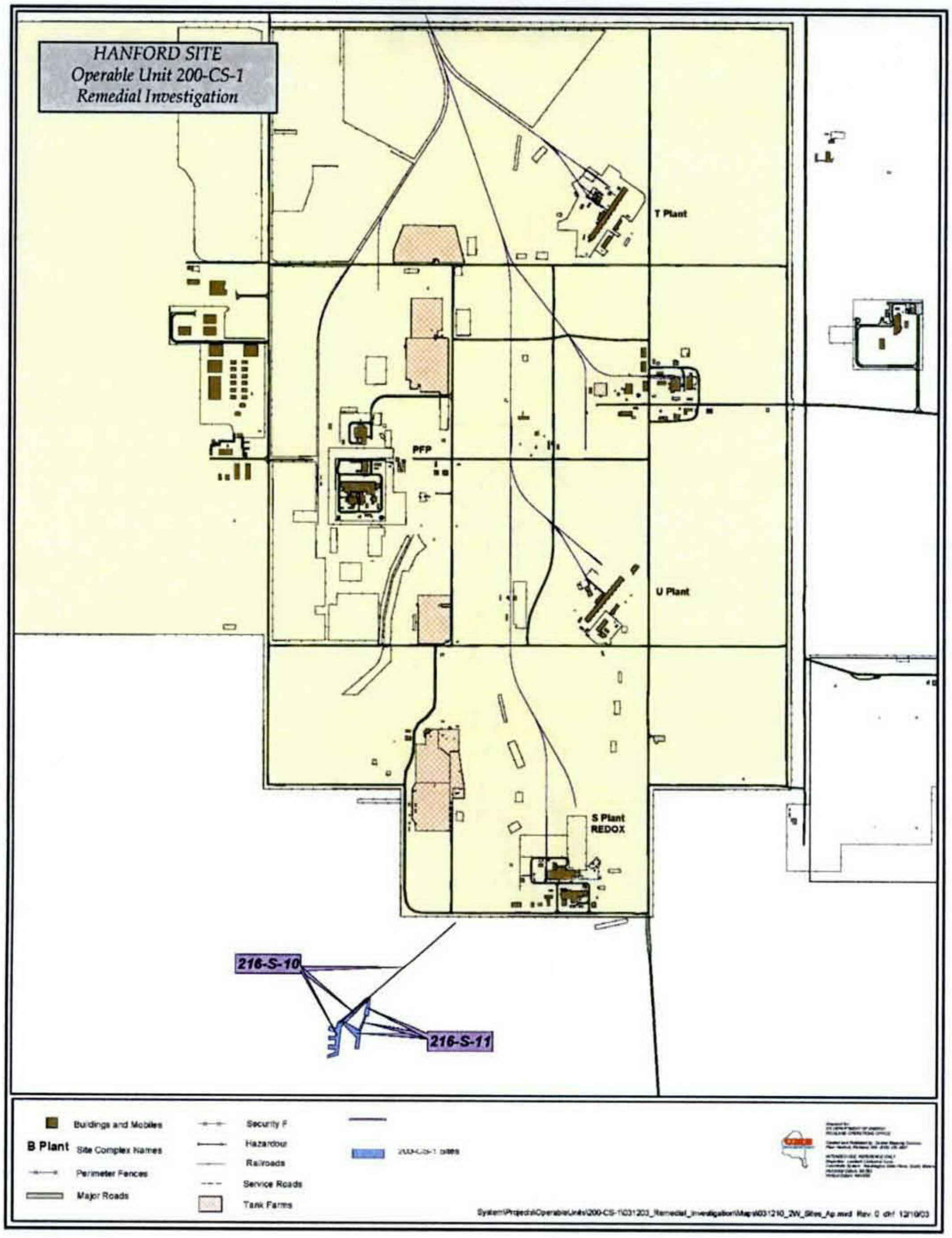
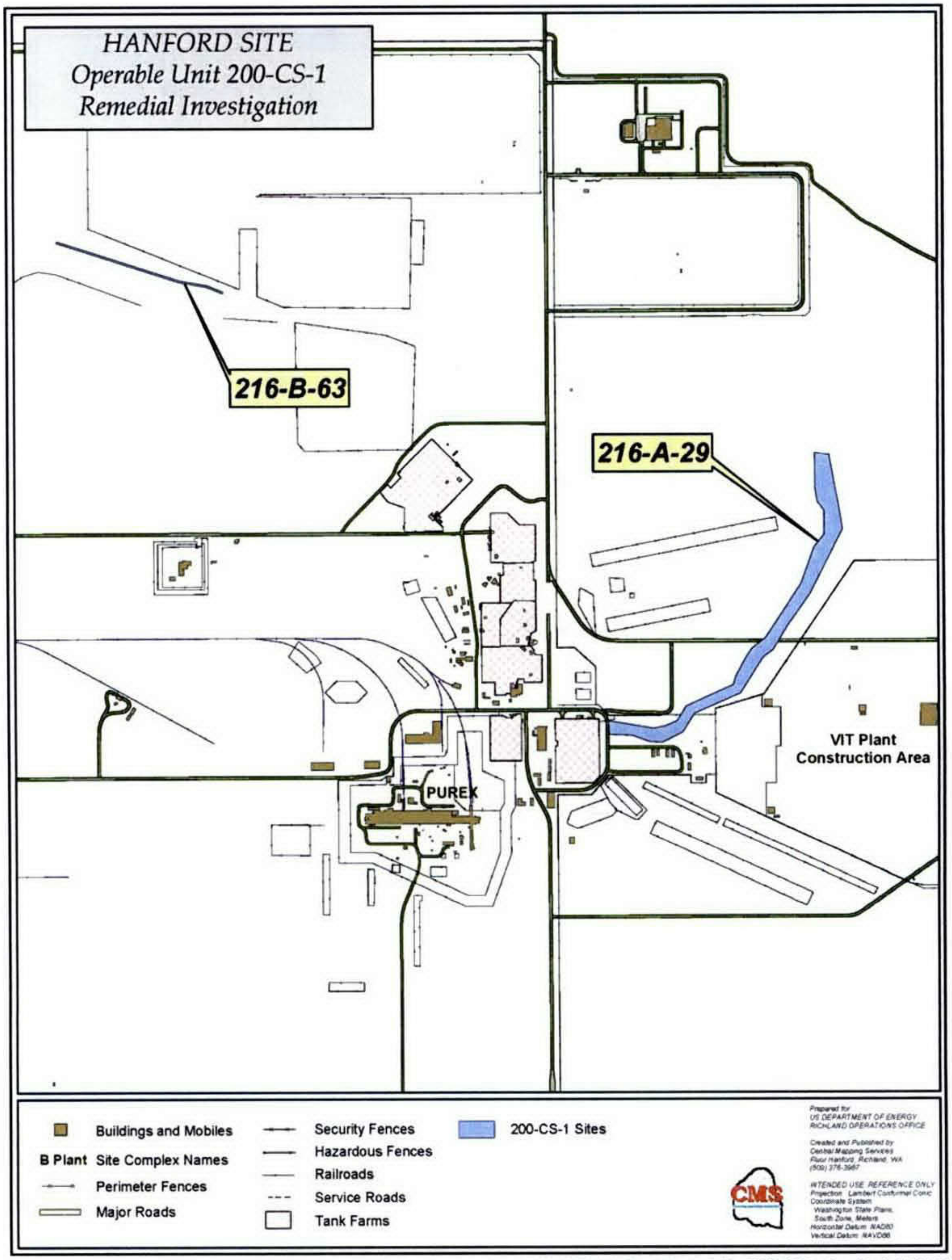


Figure 1-3. Location of the 200-CS-1 Operable Unit Waste Sites in the 200 East Area.



system\Projects\OperableUnits\200CS1\031203_Webb_Remedial_Investigation\Maps\031211_2E_Sites_Ap.mxd Rev. 0 dhf 12/11/03

Table 1-1. History of 200-CS-1 Operable Unit Key Remedial Investigation and Feasibility Study Activities.

Year	Key Remedial Investigation and Feasibility Study Activities
1989	Hanford 200 Areas on National Priorities List (40 CFR 300, Appendix B). The characterization and remediation of waste sites at the Hanford Site are addressed in the Tri-Party Agreement (Ecology et al., 1989).
1996	The final prioritized waste site groups were identified and preliminary conceptual contaminant distribution models for each waste site group were completed (DOE/RL-96-81).
1998	The Implementation Plan (DOE/RL-98-28) developed a strategy to streamline the characterization and remediation of waste sites in the 200 Areas, identified potential applicable or relevant and appropriate requirements and preliminary remedial-action objectives, and discussed potentially feasible remedial technologies that may be used in the 200 Areas.
1999	The 200-CS-1 Chemical Sewer Group Operable Unit data quality objectives process was completed, and the rationale for inclusion of contaminants of potential concern to be analyzed in the remedial investigation was documented (BHI-01276). The 200-CS-1 Operable Unit RI/FS Work Plan (DOE/RL-99-44) was completed and provided direction for characterizing chemical, radiological, and physical conditions in soils at the four representative waste sites, and identified preliminary remedial-action objectives.
2003	Sampling of the four representative waste sites was completed between November 1999 and April 2003. A number of documents summarizing data were completed in this time frame (BHI-062455; BHI-01177; PNNL-13198; BHI-01651; and WMP-17755).
2004	The quality of the sampling results and the nature and extent of contamination were documented in the remedial investigation report (DOE/RL-2004-17).
2007	Feasibility study work continued. Concurrently, a supplemental data quality objectives process identified that no supplemental remedial investigation sampling would occur for the 200-CS-1 Operable Unit waste sites (DOE/RL-2007-02).

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List."

BHI-01177, *Borehole Summary Report for the 216-B-2-2 Ditch.*

BHI-01276, *200-CS-1 Operable Unit DQO Summary Report.*

BHI-01651, *200-CS-1 Operable Unit Test Pit Summary Report for Fiscal Year 2002.*

BHI-062455, *Transmittal of Final Letter Report on Sampling and Analytical Activities at the 216-A-29 Ditch.*

DOE/RL-96-81, *Waste Site Grouping for 200 Areas Soil Investigations.*

DOE/RL-98-28, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program.*

DOE/RL-99-44, *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan.*

DOE/RL-2004-17, *Remedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit.*

DOE/RL-2007-02, *Supplemental Remedial Investigation Work Plan for the 200 Area Central Plateau Operable Units.*

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order.*

PNNL-13198, *Borehole Data Package for the 216-S-10 Pond and Ditch Well 299-W26-13.*

WMP-17755, *200-CS-1 Operable Unit Field Summary Report for Fiscal Year 2003.*

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2.0 BACKGROUND INFORMATION

2.1 OPERABLE UNITS BACKGROUND AND HISTORY

This chapter discusses the background and history of waste sites in the 200-CS-1 OU, including descriptions of the liquid-waste-generating processes, disposal processes, representative and analogous waste sites, physical setting, natural resources, cultural resources, and socioeconomics.

2.1.1 Buildings and Ancillary Facilities

The Hanford Site, established in 1943, originally was designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B, D, and F Reactors) in the 100 Areas and three chemical processing facilities (B, T, and U Plants) in the 200 Areas. Operations in the 200 East and West Areas mainly were related to separation of special nuclear materials from spent nuclear fuel (i.e., fuel withdrawn from a nuclear reactor following irradiation). When the 200 Areas were in full operation, there were eight main processing areas.

- 200 North Area – The 200 North Area was used for temporary storage of irradiated nuclear fuel and contaminated equipment.
- A Plant – In the A Plant, also known as the PUREX Plant, the tributyl-phosphate process was used to separate plutonium from irradiated fuel rods.
- B Plant – In the B Plant, the bismuth-phosphate process was used to separate plutonium from irradiated fuel rods. Recovery of cesium, strontium, and rare earth metals also was carried out at the B Plant.
- C Plant – In the C Plant, also known as the Hot Semiworks Plant, pilot-plant tests of the REDOX process were conducted before startup of the S Plant.
- S Plant – In the S Plant, the REDOX process was used to separate plutonium from irradiated fuel rods.
- T Plant – In the T Plant, the bismuth-phosphate process was used to separate plutonium from irradiated fuel rods.
- U Plant – In the U Plant, the tributyl-phosphate process was used to recover uranium from bismuth-phosphate process wastes.

- Z Plant – In the Z Plant, dibutyl phosphate, tributyl phosphate, carbon tetrachloride, and acids were used in the americium and plutonium separation and recovery process.

The following sections identify the buildings and processes involved in discharging effluent to the 200-CS-1 OU waste sites.

2.1.2 Operable Unit Description

Waste sites in the 200-CS-1 OU received liquid waste streams (principally nonradioactive dilute chemicals) from the B Plant, A Plant (PUREX), and S Plant (REDOX). Virtually every process step in the separation and radionuclide-recovery projects required the addition of solid chemicals or, more routinely, pre-mixed chemical solutions. Liquid concentrated nitric, phosphoric, and formic acids; sodium hydroxide; and aluminum nitrate were taken to the canyon buildings in railcar quantities and unloaded into the 211 Chemical Storage Tank Farm at each separation building. Most other chemical solutions were mixed onsite to preestablished concentrations and volumes in the aqueous or solvent makeup sections of the plant. Dry chemicals were weighed and added to demineralized water, also produced in the plants. Liquids such as acids and caustics were piped into large tanks in the same area. Waste inventories for the 200-CS-1 OU waste sites are not fully documented because Hanford Site practices at the time the sites were operated required only routine radioactive monitoring/surveys.

Chemical sewer wastes consisted primarily of makeup tank rinses, with lesser quantities of off-specification batches of chemicals, or overflow chemicals from tanks during aqueous makeup. Improper valving at outdoor chemical storage tanks during chemical unloading or transfer operations also may have yielded chemical sewer wastes.

The construction of separate waste sites for chemical sewer wastes generally emerged as a development in the REDOX Plant's waste treatment system and later was applied to the PUREX and waste fractionization processes. These wastes were discharged to separate ditches or ditch/pond systems.

In almost all respects, the inventory of contaminants in these waste streams is difficult to assess from process knowledge. Only incomplete records of wastes disposed to sites in this waste group exist. However, several sites were issued RCRA Part A Permits based on reported, but unreferenced, waste-discharge inventories. Most of the chemicals disposed to these streams are expected to have broken down or reacted in the environment and are expected to be largely undetectable. Some inorganic compounds (e.g., cadmium, chromium, and nitrate) could remain sufficiently intact and would be detectable in the environment. Except for chlorinated hydrocarbons, most organic compounds and reactive inorganic compounds are expected to have biodegraded or to have reacted in the environment since initial disposal.

In all cases, the waste streams were run in a noncontact manner; that is, a barrier separated the waste-stream liquids from contaminated process liquids, reducing the potential for radiological contamination of the waste streams. However, on occasion waste-stream contamination did occur. Over time, coils that circulated steam and cooling water inside chemical process tanks were known to develop pinholes and hairline cracks because of the corrosive chemicals and high thermal gradients in these tanks. These minor defects usually did not lead to contamination of the steam and cooling water, because the pressure in the pipe coils was greater than the pressure in the process or condenser vessels; however, on occasions when pressure in the coils was reduced or suspended, minor leakage through the flaws led to waste stream contamination. Other accidental releases from causes such as operator error also have contributed to contamination of the effluents discharged to the waste facilities in this OU.

Additional background information on the history of operations, important waste-generating processes, and liquid-waste disposal practices at the various processing areas is provided in Section 3.2 and Appendix H of the Implementation Plan (DOE/RL-98-28).

2.2 REPRESENTATIVE AND ANALOGOUS WASTE SITES

The concept of using analogous sites to reduce the amount of site characterization and evaluation required to support remedial action decision making is discussed in the Implementation Plan (DOE/RL-98-28). The use of this approach relies on first grouping sites with similar location, geology, waste site history, and contaminants, then choosing one or more representative sites for comprehensive field investigation, including sampling. Findings from site investigations at representative sites are extended to apply to other waste group sites that were not characterized. The analogous site approach is applied to RCRA past-practice sites only; all TSD sites are usually characterized separately. Sites that received wastes associated with specific processes first were grouped by waste category (e.g., cooling water). The waste categories then were grouped based on more specific process details. DOE/RL-96-81 describes the grouping of 200 Areas waste sites in more detail. Application of the concept takes into account similarities between waste sites such as waste-stream type, discharge history, and geology, as well as the available characterization data, to assess the nature and extent of contamination. This approach builds on information gained from the characterization of a few waste sites (representative waste sites) that are indicative of worst case and typical OU conditions. Analogous waste sites are those that have not been identified as representative waste sites within the OU. Rather, an analogous waste site is so called because it is analogous to a representative waste site. This relationship between an analogous and a representative waste site supports the evaluation of remedial alternatives for the analogous waste site.

The rationale used to align potential analogous waste sites to representative waste sites and other characterized waste sites is described below. Relationships between analogous and representative waste sites have been developed to support the evaluation of remedial alternatives for an analogous waste site based on those required for a related representative waste site. This approach is described in detail in the Implementation Plan (DOE/RL-98-28). The shared or similar characteristics of representative and potential analogous waste sites, as well as the identification of potential remedial alternatives that may apply, are central to this approach. Important considerations in the assignment of analogous waste sites include the following:

- Waste stream received
- Volume of effluent received in relation to the available pore volume for the waste site
- Types and amounts of contaminants received; contaminant inventory
- Waste-site size
- Waste-site configuration and construction (e.g., crib, trench, unplanned release)
- Expected distribution of contaminants and nature and extent of contamination
- Neighboring waste sites, structures, or utilities
- Geologic setting
- Potential for hydrologic and contaminant impacts to groundwater.

Figure 2-1 shows the process for evaluating the analogous waste sites relative to representative waste sites for the RI/FS process, from risk assessment to preferred alternative decisions to confirmatory sampling design.

The five waste sites included in the 200-CS-1 OU represent one of the 23 process-based OUs in the 200 Areas. The 200-CS-1 OU waste sites include the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, 216-S-10 Pond, and the 216-S-11 Pond. Since release of the RI Report (DOE/RL-2004-17), two other waste sites (216-W-LWC and UPR-200-W-34) included in the 200-CS-1 OU were consolidated into other waste sites or operable units. The 216-W-LWC waste site was reconsolidated from the 200-CS-1 OU to the 200-CW-5 OU. The UPR-200-W-34 waste site was reclassified from a RCRA past-practice site to a "rejected" waste site and was consolidated into the 216-S-10 Ditch waste site.

2.2.1 Assignment of Representative Waste Sites

Selection of representative waste sites generally is based on waste-stream inventory, the volume of effluent discharged, and information gained from previous characterization activities performed before the RI/FS. The four representative waste sites for the 200-CS-1 OU, the 216-A-29 Ditch, the 216-B-63 Trench, the 216-S-10 Ditch, and the 216-S-10 Pond, were identified in DOE/RL-96-81; the Implementation Plan (DOE/RL-98-28); and BHI-01276, *200-CS-1 Operable Unit DQO Summary Report*.

2.2.2 Assignment of Analogous Waste Sites

One analogous waste site in the 200-CS-1 OU has been developed for this RI/FS. This waste site, the 216-S-11 Pond, is analogous to the 216-S-10 Pond, which is discussed further in Sections 2.3.1.4 and 2.3.2.4. The 216-S-11 Pond was in operation from May 1954 to August 1965. The site provided additional leaching capacity for the disposal of water from the 216-S-10 Ditch. As such, it received the same waste stream as the 216-S-10 Pond and performed the same function as the 216-S-10 Pond.

2.3 WASTE SITE DESCRIPTIONS

This section describes the four representative waste sites for the 200-CS-1 OU: the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and the 216-S-10 Pond. These sites were created to dispose of the chemical sewer waste streams from the separation/concentration processes (e.g., PUREX Plant, REDOX Facility and B Plant cesium/strontium recovery operations). The 200 CS-1 OU consists primarily of waste sites that received unknown but probable dilute quantities of inorganic and/or organic chemicals. Radionuclide inventories are very small to negligible, although several sites have a uranium component particularly the 216-S-10 Ditch which received 215 kg of uranium in an unplanned release. Detailed descriptions of these representative waste sites are provided to support development of contaminant distribution models, to evaluate risk and to provide a baseline for implementing the analogous waste site approach in support of the RI/FS process. Data for these sites are presented in the RI Report (DOE/RL-2004-17), the Work Plan (DOE/RL-99-44), and Chapter 3.0 of this FS.

2.3.1 Background of Waste Sites

2.3.1.1 216-A-29 Ditch

The 216-A-29 Ditch received discharge from the PUREX Plant (A Plant) chemical sewer, which operated between November 1955 and July 1991. The ditch was uncovered and unlined and followed the natural topography. The ditch originated from the southeastern side of the A Tank Farm (east of the AP Tank Farm) outside the 200 East Area perimeter fence. The ditch was estimated to be 1,220 m (4,000 ft) long and 1.8 m (6 ft) wide and varied from 0.6 to 4.6 m (2 to 15 ft) deep. Structures in the 216-A-29 Ditch included a concrete spillway for the first 3 m (10 ft) from the point of inflow, a culvert under the 200 East Area perimeter road, and a wood platform and slide gate for flow control at the two earthen dams. The head end of the Ditch was modified in 1983 to allow for construction of the AP Tank Farm. The end of the Ditch connects to the 216-B-3-3 Ditch and finally to the 216-B-3 Pond.

Waste streams from the following, summarized from the stream-specific report WHC-EP-0342, Addendum 2, *PUREX Plant Chemical Sewer Stream-Specific Report*, contributed to the 216-A-29 Ditch:

- Various floor drains: 202-A Pipe and Operations Gallery; air compressor, process blower, and service blower rooms in 202-A; 211-A Pump House; and 202-A Instrument and Maintenance Shops
- 618-1 and 618-2 Flash Tanks containing heating coils, spray water, and steam condensate
- 206-A Fractionator condensers and reboiler cooling water and steam condensate
- Sink drain from the battery room, instrument shop, and maintenance shop in 202-A

- 202-A Laboratory ventilation room; heating, ventilation, and air conditioning-related drainage
- 202-A Laboratory nonradioactive clothing change room drains
- 202-A Blower Room condensate
- Overflow from various demineralized water storage tanks
- Overflow from the emergency water supply tank
- Raw water used to continuously flush the PUREX Plant chemical sewer line.

In early 1980, because of effluent monitoring requirements, the chemical sewer lines feeding the 216-A-29 Ditch required upgrades to allow for monitoring and diversion capabilities. A diversion box was upgraded and connected to the 216-A-42 Retention Basin. The Basin received chemically or radioactively contaminated diversions from the PUREX Plant chemical sewer line, cooling water line, and steam condensate discharge (Vitro-R-642, *Title I Report, Chemical Sewer Sampling, Monitoring, Flow Totalizing and Diverting System (PUREX), Project B-190*).

During 1990, plans were developed and approved to discontinue discharges to and close the 216-A-29 Ditch (WHC-SD-EN-AP-031, *Interim-Status Groundwater Quality Assessment Program Plan for the 216-A-29 Ditch*), and in 1991 all discharges were discontinued.

Stabilization of the 216-A-29 Ditch was performed in three phases from July to October 1991. In the first phase, bulldozers were used to push the top layers of soil from within the surface contamination zone and the ditch spoil piles into the bottom of the 216-A-29 Ditch. The concrete spillway was covered with clean soil, and the ends of the culvert were filled with concrete. The slide-gate structure and the two earthen dams were lowered, and the wood platform and associated hardware were demolished and disposed of in the ditch.

In the second phase, the consolidated soils were covered with clean material. In the section of the 216-A-29 Ditch inside the 200 East Area perimeter fence, fill was brought up to the surrounding grade. The fill was brought from the Grout Project spoil pile and the 216-B-3 Main Pond spoil pile. Outside of the 200 East Area fence, all clean fill came from the upper banks of the 216-A-29 Ditch. The fill was placed in a series of terraces progressing down the ditch. A terrace was placed for every 1.8 m (6 ft) decrease in streambed elevation. The face of each terrace and earth dam was armored with 15 to 25 cm (6 to 10 in.) of gravel. In all, 11 terraces were constructed.

The third phase consisted of revegetating and reposting the area disturbed by stabilization activities. A high-nitrogen fertilizer was spread over the area. Siberian wheatgrass (*Agropyron sibericum*) and thickspike wheatgrass (*Pascopyrum smithii*) then were planted, followed by the placement of straw mulch. After surface radiological surveys were completed and soil samples were collected and analyzed, the area was reposted as an

Underground Radioactive Material Area. The Underground Radioactive Material Area encompasses 2.6 ha (6.4 ac.).

In 2001, sampling was conducted at the 216-A-29 Ditch in an area where a proposed waste-transfer line from the AP Tank Farm to the Waste Treatment Plant crossed the ditch. Approval of the construction of the transfer line over the 216-A-29 Ditch was granted by Ecology in June 2002 (External Letter, "Re: Waste Transfer Line Crossing Over the 216-A-29 Ditch Treatment, Storage, and Disposal Unit, 02-RCA-0301," [Price 2002]).

The 216-A-29 Ditch received both dangerous and radioactive liquid effluent at a rate of 22,700,000 L/d (6,000,000 gal/d) at an average flow rate of 3,760 L/min (970 gal/min). The discharges, consisting of acidic and caustic wastes, were the result of backwashes from the regeneration of demineralizer columns in the PUREX Plant (A Plant). The dangerous waste received included corrosive waste (Dangerous Waste Code D002) consisting primarily of acidic waste, sulfuric acid, and sodium hydroxide; toxicity characteristic waste (D006); and state-only waste WT02. Hydrazine (Dangerous Waste Code U133) also was discharged to the Ditch, along with heavy metals including cadmium nitrate and lead (DOE/RL-99-44). Operating records for the 200-CS-1 OU waste sites do not contain sufficient detail to determine complete radionuclide and chemical inventories for all years of operation. However, Table 2-1 is based on some historical data and lists chemicals known to have been released to the 216-A-29 Ditch between 1983 and 1987.

2.3.1.2 216-B-63 Trench

The 216-B-63 Trench was constructed before 1970 as a percolation trench to receive emergency cooling water and chemical sewer waste from the B Plant (221-B Canyon Building). The Trench was an open, unlined, artificial earthen trench that was closed at one end (it did not convey effluent to another facility). The trench was located entirely within the 200 East Area perimeter fence and was approximately 427 m (1,400 ft) long, 1.2 m (4 ft) wide, and averaged 3 m (10 ft) deep. The side slope was 1.5:1. The first 3.1 m (10 ft) of the trench contained a 5.1 cm (2 in.) rockfill. A 40.6 cm (16 in.) diameter inlet pipe approximately 1.5 m (5 ft) long entered the trench 1 m (3 ft) below grade. The trench was taken out of service in 1992.

Contributors to the 216-B-63 Trench included the 2902-B High Tank (potable sanitary water), cooling water from the B Plant and Waste Encapsulation and Storage Facility air-compressor aftercoolers, some of the 221-B Canyon Building steam condensate, and the demineralizer effluent. Minor contributions came from chemical-makeup overflow systems (e.g., sodium hydroxide, sodium nitrite), air conditioning units, and space heaters. These minor contributions were determined to have been controlled to levels below dangerous-waste designation limits. Specific sources of each are presented in the stream-specific report (WHC-EP-0342, Addendum 6, *B Plant Chemical Sewer Stream-Specific Report*).

The 216-B-63 Trench received B Plant cooling waste and in-tank solidification cooling water from March 1970 to May 1970 (ARH-2015, *Radioactive Liquid Wastes Discharged to Ground in the 200 Areas During 1970*). The Trench began receiving cooling water on March 22, 1970, after an unplanned release (UPR-200-E-138) of 1,000 Curies of strontium-90 into the 216-B-2-2 Ditch. In May 1970, the trench began receiving B Plant chemical-sewer effluent. The B Plant chemical-sewer pipeline went directly to the 216-B-63 Trench. The 207-B Retention Basin was used to retain low-level, nonhazardous liquid waste (cooling water) en route to the 216-B-2 series ditches (located east of the structure). Chemical-sewer waste did not pass through the 207-B Retention Basin, but cooling water was routed through the retention basin from March to May 1970. In August 1970, the bottom and sides of the 216-B-63 Trench were dredged out as a result of the unplanned release. The dredgings had readings of approximately 3,000 Ci/min of beta-gamma activity and were buried in the 218-E-12B Burial Grounds (RHO-CD-798, *Current Status of the 200 Area Ponds*). The 216-B-2 series ditches, which are parallel to the 216-B-63 Trench, initially were used to dispose of liquid waste from the 207-B Retention Basin. The basin is located 610 m (2,000 ft) northeast of the B Plant, immediately south of the B Tank Farms.

An upgrade to the chemical-sewer system that discharged to the 216-B-63 Trench was planned in 1980 after it was estimated that a volume of more than 1,140,000 L/d (300,000 gal/d) could be leaking into the ground from the sewer (RHO-CD-1010, *B Plant Chemical Sewer System Upgrade*). Leakage had been documented at the chemical sewer for about 10 years from the date of this recommended upgrade. About half of this amount of liquid was lost by leakage before it reached a measuring station at the 207-B Retention Basin. The pipelines that were known or suspected of leaking were relined or replaced by Project B-496 in 1985. The 38 cm (15-in.) vitrified clay pipeline located downstream of manhole No. 12, the beginning of the TSD unit piping and the effluent conveyance pipe to the 216-B-63 Trench site, was not replaced, because it did not have known leakage problems (SD-496-CDR-001, *Conceptual Design Report Chemical Sewer Upgrade, 221-B Project B-496*). The results of the chemical and radiological analyses of the contaminated sediments excavated during the pipeline upgrade were not found. The leak occurred at the head end of the pipeline adjacent to the B Plant facility boundary.

The trench was isolated and interim stabilized in December 1994 and January 1995. The weir box at the head end of the trench was filled with concrete, and the valve stems at the 207-B Retention Basin were cut off. A prestabilization civil survey was performed, the trench was covered with clean soil and marked with concrete posts, and a post-stabilization civil survey was performed.

The 216-B-63 Trench received both dangerous and radioactive liquid effluent. The only documented hazardous effluent discharged in the past consisted of regeneration solutions from the B Plant demineralizers (271-B Building). The dangerous waste received from 1970 until October 1985 included corrosive waste (Dangerous Waste Code D002) consisting primarily of sodium hydroxide, sulfuric acid, and sodium nitrate. After 1985, effluents were treated to maintain a combined pH of between 4 and 10 and no longer were considered dangerous waste. As of January 1999 (DOE/RL-96-81), radiological inventory at the trench includes 21.2 kg of total uranium, 0.57 kg of total plutonium, 0.035 kg of Am-241, 0.51 kg of Cs-137, and 1.94 kg of Sr-90. The approximate average flow rate of wastewater discharged to the 216-B-63 Trench varied from 378,000 to 1,408,000 L/d (100,000 to 400,000 gal/d). Approximately 68,100,000 kg/y (or 473,000 L/d [125,000 gal/d]) of corrosive waste were managed in the 216-B-63 Trench for the period from 1970 to 1992 (DOE/RL-99-44).

2.3.1.3 216-S-10 Ditch

The 216-S-10 Ditch was an uncovered, unlined artificial ditch that received wastewater from the REDOX Plant (S Plant). The ditch originated outside the perimeter fence and was estimated to be 686 m (2,250 ft) long, 1.8 m (6 ft) wide, and averaged 1.8 m (6 ft) deep.

The 216-S-10 Ditch started receiving discharge from the REDOX Plant (S Plant) in August 1951. This Ditch was part of a system that includes the 216-S-10 and 216-S-11 Ponds. In addition to these three sites, during May 1954 (HW-43121, *Tabulation of Radiological Liquid Waste Disposal Facilities*) an approximate 4,048 m^2 (1 a.) overflow from the Ditch released an estimated 215 kg of uranium from the Ditch in the southeast dike of the 216-S-11 Pond. This unplanned release is referenced as UPR-200-W-34. After the unplanned release, the ditch was dredged, and the sludge was removed and placed in unknown low spots on both sides of the Ditch. The Ditch then was covered with 0.6 m (2 ft) of soil.

Approximately 50 waste streams contributed to the 216-S-10 Ditch (WHC-EP-0342, Addendum 9, *S Plant Wastewater Stream-Specific Report*). The routine waste stream sources included the compressor cooling water from the 202-S Building and the sanitary water overflow from the water tower. The remaining sources were infrequent additions and included 202-S Building floor drains and funnel drains, 211-S Tank Farm (a liquid-chemical storage area) pump drains, tank drains, station drains, chemical-sewer line man-holes, and 276-S Building floor drains. The effluent to the chemical sewer was composed of approximately 60 percent REDOX Plant raw water, 20 percent sanitary water, and 20 percent steam condensate.

The 216-S-10 Ditch and Pond system was developed in February 1954, when it became apparent that more leaching surface was needed. At that time, the 216-S-10 Pond was constructed to provide more leaching surface. The two 216-S-11 Leach Pond lobes on the southeast side of the 216-S-10 Ditch were constructed to provide even more leaching surface in May 1954. Plugging of the system occurred in part because of inadvertent dumping of aluminum nitrate nonahydrate solutions. In 1955, 0.6 m (2 ft) of sediment were dredged from the bottom of the 216-S-10 Ditch to improve water percolation. The contaminated sediments were buried in excavation pits along the sides of the ditch. The depth and location of the excavation pits are unknown (RHO-CD-798).

The south end of the 216-S-10 Ditch remained in use until 1984, when the ditch was backfilled and stabilized. The north end of the Ditch remains open to a depth of approximately 3 m (10 ft), and last received discharges during 1991 (BHI-00176, *S Plant Aggregate Area Management Study Technical Baseline Report*). The supplying pipeline was plugged with concrete near the outfall in July 1994. It is estimated that approximately 505 m (1,660 ft) of the ditch is open, and 180 m (590 ft) was backfilled and stabilized.

A hazardous waste discharge from the Chemical Engineering Laboratory to the 216-S-10 Ditch and Pond occurred in September 1983. The 420 L (110 gal) of double-shell slurry simulant, consisting of sodium nitrate (46 percent), sodium hydroxide (41 percent), and small quantities of sodium phosphate, sodium fluoride, sodium chloride, and potassium chromate, were sent via the sewer to the ditch and pond. This discharge exhibited the dangerous waste characteristics of ignitability (D001), corrosivity (D002), characteristic waste (D007), and toxic state-only waste (WT01, WT02). Approximately 450 kg (1,000 lb) of dangerous waste were discharged to the 216-S-10 Ditch and Pond system.

As of January 1999 (DOE/RL 96-81), radiological inventory at the ditch includes 199 kg of total uranium, 0.1 kg of total plutonium, 0.015 kg of Am-241, 1.0 kg of Cs-137, and 0.86 kg of Sr-90. During operations, the maximum volume of wastewater discharged to the 216-S-10 Ditch and Pond was approximately 568,000 L/d (150,000 gal/d).

2.3.1.4 216-S-10 Pond

The 216-S-10 Pond received discharge from the REDOX Plant (S Plant). This Pond was part of a system that included the 216-S-10 Ditch and the 216-S-11 Pond. The pond was dug in 1954 at the southwest end of the 216-S-10 Ditch to provide additional leaching surface. The 216-S-10 Pond was an irregular-shaped, artificial pond that covered approximately 20,234 m^2 (5 ac.) and included four finger-leach trenches. The pond was approximately 2.4 m (8 ft) at its deepest point. The Pond was fed by the 216-S-10 Ditch. Both the ditch and pond were designed to dispose of liquids through percolation into the soil column.

Contributors to the pond are similar to those of the 216-S-10 Ditch. In 1984, concurrent with the 216-S-10 Ditch, the 216-S-10 Pond was stabilized (DOE/RL-99-44).

2.3.2 Summary of Data Collection Activities

This section summarizes the data-collection activities performed during the 200-CS-1 OU RI, as well as data contained in WMP-17755, *200-CS-1 Operable Unit Field Summary Report for Fiscal Year 2003*; BHI-01651, *200-CS-1 Operable Unit Test Pit Summary Report for Fiscal Year 2002*; PNNL-13198, *Borehole Data Package for the 216-S-10 Pond and Ditch Well 299-W26-13*; BHI-062455, *Transmittal of Final Letter Report on Sampling and Analytical Activities at the 216-A-29 Ditch*; and BHI-01177, *Borehole Summary Report for the 216-B-2-2 Ditch*. This section also covers drilling, sampling, analysis, and geophysical logging.

The RI was conducted from November 1999 to April 2003 at the four representative waste sites, in accordance with the Work Plan (DOE/RL-99-44). Data were collected to characterize the nature and vertical extent of chemical and radiological contamination and the physical conditions in the vadose zone underlying the historical boundaries of the four waste sites. Twelve test pits were excavated and sampled to determine the vertical and lateral extent of contamination within the area historically defined as the waste-site boundary. Distribution of the test pits is as follows:

- Three test pits at the 216-A-29 Ditch
- Two test pits at the 216-B-63 Trench
- Three test pits at the 216-S-10 Ditch
- Four test pits at the 216-S-10 Pond.

Samples were collected and analyzed for radionuclides, metals, anions, polychlorinated biphenyls, volatile and semivolatile organics, and physical properties. The data collected were considered to be of sufficient quantity and quality to support qualitative risk-assessment activities and to support evaluation of remedial alternatives and identify preferred remedial actions, as designed in the Work Plan (DOE/RL-99-44).

In addition, four boreholes, one at each representative waste site, were drilled, sampled, and logged to groundwater with a high-resolution Spectral Gamma-Ray Logging System (SGLS) to provide continuous vertical logs of gamma-emitting radionuclides, and were logged with a Neutron Moisture-Logging System (NMLS) to identify moisture changes. Two additional existing wells, 299-W26-6 and 699-32-77, were logged with a high-resolution SGLS. Supplemental data for the 216-A-29 Ditch and 216-B-63 Trench were included in the RI. Two additional test pits (Areas 8 and 9) were sampled at the 216-A-29 Ditch in July 1998. One additional borehole (Borehole B8079 from the 216-B-2-2 Ditch) near the 216-B-63 Trench was sampled in January 1998, and a few deep vadose-zone samples were included in the RI. These activities are summarized not only in the RI Report (DOE/RL-2004-17), but also in BHI-01651 and WMP-17755.

The test-pit locations, shown in Figures 2-2 through 2-4, were prepared by removing 0.3 to 0.6 m (1 to 2 ft) of topsoil from the site. The test pits were excavated to a maximum depth of 7.6 m (25 ft) below ground surface (bgs) using a track-hoe. Samples were obtained directly from the track-hoe bucket at intervals of approximately 0.7 m (2.5 ft). Before being placed in a sample jar, soil samples were screened in the field for alpha and beta-gamma radioactivity to assist in selecting sample points, to support worker health and safety and to provide shipping information. A radiological control technician using field instruments performed radiological screening. Samples were analyzed for chemical, radiological, and physical properties. The test pits were backfilled in the reverse order from the order in which they were excavated, using the trackhoe. A front-end loader then was used to backfill the site with topsoil and/or gravel.

The boreholes, shown in Figures 2-2 through 2-4, were drilled using a cable-tool drill rig and were advanced to total depth using drive barrels and split-spoon samplers. Split-spoon samplers were the primary sampling device used to collect chemical, radiological, and physical property samples. The three boreholes were decommissioned with granular bentonite after reaching total depth, in accordance with WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells”.

Drilling, test-pit excavation, surface and borehole geophysical surveys, and soil sampling and analysis were conducted during the field activities. All boreholes and test pits were completed, and all samples were collected and analyzed for contaminants of potential concern identified in BHI-01276 and the Work Plan (DOE/RL-99-44).

2.3.2.1 216-A-29 Ditch Characterization

Borehole B8826 was drilled and sampled from the ground surface to a depth of 83.2 m (273 ft), in the 216-A-29 Ditch east of the AP Tank Farm in fiscal year 2003 (Figure 2-2). Test pits AD-1 through AD-3 were excavated and sampled at the 216-A-29 Ditch in fiscal year 2002 (BHI-01651), and details were summarized in the RI Report (DOE/RL-2004-17). Data collected from Test Pit AD-3 were in addition to the data required by the Work Plan and were used to support the decision-making process for locating a proposed waste-transfer line to the Waste Vitrification Plant as part of Project W-211. The characterization activities for the AD-3 site were performed in accordance with BHI-01562, *Sampling and Analysis Instruction for the 216-A-29 Ditch for Project W-211.* Borehole B8826 was drilled through the 216-A-29 Ditch and sampled during fiscal year 2003. The borehole was terminated at 83.2 m (273 ft) and was logged using a high-resolution SGLS and an NMLS. The borehole was drilled to better define stratigraphy and to assess the nature and vertical extent of chemical and radiological contamination, as well as to determine the physical properties of the soil beneath the waste site.

2.3.2.2 216-B-63 Trench Characterization

Borehole B8827 was drilled and sampled, and test pits BT-1 and BT-2A were excavated and sampled in the 216-B-63 Trench, located east of the B Tank Farm (Figure 2-3). The two samples scheduled to be taken from Test Pit BT-1 at depths of 6.1 to 7.6 m (20 and 25 ft) were not obtained, because the test pit caved in excessively. Excavation equipment regulated for use in contaminated environments was unavailable, so sampling at Test Pit BT-2 in fiscal year 2002 was terminated on November 2, 2001, after sampling at the 2.3 to 2.6 m (7.5 to 8.5 ft) depth. At that point, the soil was returned to the sampling pit in the reverse order from that at which it was excavated. Test Pit BT-2A was excavated and sampled to 7.6 m (25 ft) on November 11, 2002. This test pit was designated "BT-2A" to distinguish it from the fiscal year 2002 operations. Borehole B8827 was drilled through the 216-B-63 Trench and sampled during fiscal year 2003. It was terminated at 31.4 m (103 ft) and was logged using a high-resolution SGLS and an NMLS. The borehole was drilled to better define stratigraphy and to assess the nature and vertical extent of chemical and radiological contamination, as well as to determine the physical properties of the soil beneath the waste site.

2.3.2.3 216-S-10 Ditch Characterization

Borehole B8828 was drilled and sampled adjacent to the 216-S-10 Ditch, and Test Pits SD-1, SD-2, and SD-3 were excavated and sampled in the 216-S-10 Ditch, located in the 200 West Area (Figure 2-4). Borehole B8828 was completed as a RCRA monitoring well and renumbered as well 299-W26-14 to support the RCRA monitoring program. It was drilled through the 216-S-10 Ditch and sampled during fiscal year 2003. The borehole was terminated at 81.4 m (267 ft), and was logged using a high-resolution SGLS and an NMLS. The borehole was drilled to better define stratigraphy and to assess the nature and vertical extent of chemical and radiological contamination, as well as to determine the physical properties of the soil beneath the waste site. An additional test pit, SD-3, was excavated in the 216-S-10 Ditch at the original location of planned Borehole B8828 to gather characterization data below the waste site.

2.3.2.4 216-S-10 Pond Characterization

Test Pits SP-1, SP-2, SP-3, and SP-4 were excavated and sampled in the 216-S-10 Pond (Figure 2-4). Borehole B8817 was drilled adjacent to the 216-S-10 Pond and sampled in

FY 1999. Additional details are provided in PNNL-13198. Borehole B8817 was completed as a RCRA monitoring well and renumbered as well 299-W26-13. The borehole was logged using a high-resolution SGLS and an NMLS. It was drilled to better define stratigraphy and to assess the nature and vertical extent of chemical and radiological contamination, as well as to determine the physical properties of the soil beneath the waste sites.

2.4 PHYSICAL SETTING

The following sections briefly describe the meteorology, topography, and hydrogeologic frameworks for the 200-CS-1 OU waste sites. Additional discussions are provided in DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*; PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*; PNNL-13910, *Hanford Site Environmental Report for Calendar Year 2001*; and PNNL-6415, *Hanford Site National Environmental Policy Act (NEPA) Characterization.*

2.4.1 Meteorology

The Hanford Site lies east of the Cascade Mountains and has a semiarid climate caused by the rain-shadow effect of the mountains. Climatologic data are monitored at the Hanford Meteorological Station and other locations throughout the Hanford Site. From 1945 through 2001, the recorded maximum temperature was 45 °C (113 °F), and the recorded minimum temperature was –30.6 °C (–23 °F) (PNNL-6415). The two extremes occurred during August and February, respectively. The monthly average temperature ranged from a low of –0.24 °C (31.7 °F) in January to a high of 24.6 °C (76.3 °F) in July. The annual average relative humidity is 54 percent (PNNL-6415).

Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February (PNNL-6415). Normal annual precipitation is 17.7 cm (6.98 in.). Because this area typically receives less than 25.5 cm (10 in.) of precipitation a year, the climate is considered to be semiarid (PNNL-6415).

The prevailing wind direction at the Hanford Monitoring Station is from the northwest during all months of the year (PNNL-6415). Monthly average wind speeds are lowest during the winter months and average about 3 m/s (6 to 7 mi/h). The highest average wind occurs during the summer and is about 4 m/s (8 to 9 mi/h). The record wind gust was 35.7 m/s (80 mi/h) in 1972.

2.4.2 Topography

The 200-CS-1 OU is located on the 200 Areas Central Plateau, which is a broad, relatively flat, prominent terrace (Cold Creek Bar) near the center of the Hanford Site. The Cold Creek Bar was formed about 13,000 years ago during the last cataclysmic flood from glacial Lake Missoula. The Cold Creek Bar trends generally east-west with elevations between 197 and 225 m (647 and 740 ft) above mean sea level. The plateau drops off rather steeply to the north and northwest into a former flood channel with elevation changes of between 15 and 30 m (50 and 100 ft). The plateau decreases more gently in elevation to the south into the Cold Creek Valley and to the east toward the Columbia River. Most of the 200 West Area and the southern half of the 200 East Area are situated on the Cold Creek Bar, while the northern half of the 200 East Area lies within the former flood channel. A secondary flood channel running southerly from the main channel bisects the 200 West Area. Surface elevations in the vicinity of the 200 West Area sites range from approximately 198 to 204 m (650 to 670 ft). Surface elevations in the vicinity of the 200 East Area sites range from approximately 177 to 207 m (580 to 680 ft). The buried former river and flood channels may provide preferential pathways for groundwater and contaminant movement.

2.4.3 Geology

The 200-CS-1 OU is located in the Pasco Basin, one of several structural and topographic basins of the Columbia Plateau. Basalts of the Columbia River Basalt Group and a sequence of suprabasalt sediments underlie the 200-CS-1 OU waste sites. From oldest to youngest, the major geologic units of interest are the Elephant Mountain Member, the Ringold Formation, the Cold Creek unit, the Hanford formation, and surficial deposits. Figure 2-5 shows a generalized stratigraphic column for the 200 Areas. Geologic cross sections of the waste sites that show the depth, thickness, and variability of these geologic units are shown in Figures 2-6 through 2-8.

Elephant Mountain Member. The Elephant Mountain Member is the uppermost basalt unit (i.e., bedrock) in the 200 Areas. Except for a small area north of the 200 East Area boundary where it has been eroded away, the Elephant Mountain Member is laterally continuous throughout the 200 Areas. The RI field investigations did not penetrate to the basalt. Based on previous investigations and nearby wells, the top of basalt is approximately 67 to 119 m (220 to 390 ft) deep at the 216-A-29 Ditch, 81 m (264 ft) deep at the 216-B-63 Trench, 173 to 179 m (567 to 587 ft) deep at the 216-S-10 Ditch, and 179 m (587 ft) deep at the 216-S-10 Pond (DOE/RL-99-44; PNNL-13198; WMP-17755; PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*; and PNNL-13858, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*). The basalt is overlain by the Ringold Formation, except at the 216-B-63 Trench and the northern portion of the 216-A-29 Ditch, where the basalt is directly overlain by the Hanford formation (DOE/RL-99-44; PNNL-12261) and possibly gravels of the Cold Creek unit (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for the Post-Ringold-Formation Sediments Within the Central Pasco Basin*).

Ringold Formation. The Ringold Formation consists of an interstratified fluvial-lacustrine sequence of unconsolidated to semiconsolidated clay, silt, sand, and granule-to-cobble gravel deposited by the ancestral Columbia River. These sediments consist of the following four major units, from oldest to youngest (see Figure 2-5): the fluvial gravel and sand of unit 9 (basal coarse), the buried soil horizons, overbank, and lake deposits of unit 8 (lower mud), the fluvial sand and gravel of unit 5 (upper coarse), and the lacustrine mud of unit 4 (upper fines). Units 9 and 5 consist of a silty-sandy gravel with secondary lenses and interbeds of gravelly sand, sand, and muddy sands to silt and clay. Unit 8 (lower mud) consists mainly of silt and clay. Unit 4 (upper fines) consists of silty overbank deposits and fluvial sand. Units 6 and 7 are not present in the 200 West and 200 East Areas (PNNL-12261; PNNL-13858). The Ringold Formation is overlain by the Cold Creek unit in the 200 West Area and in parts of the 200 East Area.

Cold Creek Unit. The Cold Creek unit is the new standardized name for several post-Ringold Formation and pre-Hanford formation units present in the 200 West and East Areas (DOE/RL-2002-39). The Cold Creek unit includes the former Plio-Pleistocene unit, caliche, early Palouse soil, Pre-Missoula gravels, and sidestream alluvial facies described in previous Hanford Site reports. The Cold Creek unit has been divided into five lithofacies. The five lithofacies units are differentiated based on grain size, sedimentary structure, sorting, fabric, and mineralogy as follows:

- Fine-grained, laminated to massive (fluvial-overbank and/or eolian deposits, formerly the early Palouse soil)
- Fine-to coarse-grained, calcium-carbonate cemented (calcic paleosol, formerly the caliche)
- Coarse-grained, multilithic (mainstream alluvium, formerly the Pre-Missoula gravels)
- Coarse-grained, angular, basaltic (colluvium)
- Coarse-grained, rounded, basaltic (sidestream alluvium, formerly sidestream alluvial facies) (DOE/RL-2002-39).

Based on the Cold Creek unit facies distribution from DOE/RL-2002-39, the Cold Creek unit present beneath the 200 West Area waste sites includes the overbank/eolian and the calcic paleosol facies while the Cold Creek unit present beneath the 200 East Area waste sites consists of the coarse-grained multilithic facies. Descriptions of the five lithofacies units, depositional environments, and association with previous site nomenclature are shown in Table 2-2.

Hanford Formation. The Hanford formation is the informal stratigraphic name used to describe the Pleistocene cataclysmic flood deposits within the Pasco Basin. The Hanford formation consists predominantly of unconsolidated sediments that range from boulder-size gravel to sand, silty sand, and silt. The sorting ranges from poorly sorted (for gravel facies) to well sorted (for fine sand and silt facies). The Hanford formation is divided into three main lithofacies: interbedded sand- to silt-dominated (formerly Touchet Beds or slackwater facies); sand-dominated (formerly sand-dominated flood facies), and gravel-dominated (formerly Pasco Gravels) that have been further subdivided into 11 textural-structural lithofacies (DOE/RL-2002-39). Beneath the 200-CS-1 OU waste sites, the Hanford formation includes the gravel-dominated and sand-dominated facies. The gravel-dominated facies are cross-stratified, coarse-grained sands and granule-to-boulder gravel. The gravel is uncemented and matrix poor. The sand-dominated facies are well-stratified fine- to coarse-grained sand and granule gravel. Silt in these facies is variable and may be interbedded with the sand. Where the silt content is low, an open-framework texture is common. Clastic dikes are common in the Hanford formation but rare in the Ringold Formation (DOE/RL-98-28; DOE/RL-2002-39). They appear as vertical to subvertical sediment-filled structures, especially within sand- and silt-dominated units. The Hanford formation is locally overlain by veneers of surficial deposits.

Surficial Deposits. Surficial deposits include Holocene eolian sheets of sand that form a thin veneer over the Hanford formation across the site, except in localized areas where the deposits are absent. Surficial deposits consist of very fine to medium-grained sand to occasionally silty sand. Silty deposits less than 1 m (3 ft) thick also have been documented at waste sites where fine-grained, wind-blown material has settled out through standing water over many years. Fill material was placed in and over representative waste sites during construction and for contamination control. The fill consists of reworked Hanford formation sediments and/or surficial sand and silt. The thickness of the fill material varies from 0.3 to 2.1 m (1 to 7 ft) at the representative waste sites (BHI-01651, WMP-17755).

2.4.4 Hydrostratigraphy

Hydrostratigraphy is the description and classification of mapable units, as related to their hydrologic properties. Vadose-zone hydrostratigraphic units within the 200-CS-1 OU include the Ringold Formation, the Cold Creek unit, the Hanford formation, and surficial deposits (see Figure 2-5). The unconfined-aquifer hydrostratigraphic units within the 200-CS-1 OU include the Ringold Formation and the Hanford formation. The base of the unconfined aquifer is the top of the Ringold Formation unit 8 (lower mud) or the top of basalt (Elephant Mountain Member).

Vadose Zone. The vadose zone is the area between the ground surface and the water table. At the 200 East Area representative waste sites, the vadose zone varies from about 82.4 m (270.2 ft) thick at the 216-A-29 Ditch to about 75 m (245 ft) thick at the 216-B-63 Trench. The vadose zone is entirely within Hanford formation sediments at the 216-B-63 Trench. At the 216-A-29 Ditch, the vadose zone is predominantly Hanford formation sediments, with a thin section of Ringold Formation sediments above the water table. Note that although some facies of the Cold Creek unit have been identified beneath 200 East Area (DOE/RL-2002-39), it has not been specifically identified beneath either the 216-A-29 Ditch or the 216-B-63 Trench.

At the 200 West Area waste sites, the vadose zone varies from 68 m (223 ft) thick at the 216-S-10 Ditch to 61 m (200.5 ft) thick at the 216-S-10 Pond with groundwater flow generally to the east-southeast. Sediments within the vadose zone at these waste sites include the Hanford formation, the Cold Creek unit, and part of the Ringold Formation unit 5.

Moisture content in the 200 Areas vadose zone typically ranges between 2 and 10 percent under ambient conditions (DOE/RL-98-28) but historically has ranged widely from 10 percent to saturation (perched water) at liquid-waste disposal sites. Before 1995, liquid-waste sites provided a significant driving force for contaminant transport. With the reduction of artificial recharge in the 200 Areas since 1995, the downward flux of liquid in the vadose zone beneath waste sites has been decreasing. However, moisture content and downward flux of moisture in the vadose zone near waste sites is expected to remain elevated over preoperational conditions for some time. Artificial recharge occurred when effluent such as cooling water was disposed of to the ground. Zimmerman et al. (1986) reports in *Hanford Site Water Table Changes 1950 Through 1980 – Data Observations and Evaluation* that between 1943 and 1980, 6.33 X 10^{11} L (1.67 X 10^{11} gal) of liquid wastes were discharged to the soil column. Most sources of artificial recharges have been halted. The artificial recharge that does continue is largely limited to liquid discharges from sanitary sewers; 2 state-approved land disposal structures; and 140 small-volume, uncontaminated, miscellaneous streams. In the absence of artificial recharge, recharge from natural precipitation becomes the dominant driving force for moving the contamination remaining in the vadose zone to the groundwater. Estimates of recharge from precipitation range from 0-10 cm/y (0-4 in/y) and are largely dependent upon soil texture and the type and density of vegetation.

Data collected with the neutron-moisture logging tool indicate that volumetric moisture content beneath the 200 West Area representative waste sites ranged from 2 to 15 percent over the logged intervals. The highest moisture content correlated with the top of the Cold Creek unit at 41 m (134 ft) depth at the 216-S-10 Pond borehole (PNNL-13198). Calibration data were not available for the casing sizes used in drilling the 200 East Area representative waste site boreholes, so volumetric moisture contents were not calculated for the neutron logs from these boreholes (WMP-17755).

The borehole drilled at the 216-A-29 Ditch encountered perched water at about 78.6 to 78.9 m (258 to 259 ft) bgs that was sitting atop a 1.4 m (4.5-ft-) thick very dense, compacted silt/clay layer of the Ringold Formation.

A limited number of soil samples were collected to determine moisture content, grain-size distribution, and bulk density. Laboratory moisture content ranged from 2.5 to 14.3 percent (equivalent to 4.9 to 27.9 volumetric moisture percent). Bulk densities ranged from 1.38 to 2.07 g/cm^3. The results were published in WMP-17755, and PNNL-13198.

Unconfined Aquifer. The uppermost or unconfined aquifer beneath the 216-A-29 Ditch is approximately 2 to 24 m (7 to 79 ft) thick and is contained within sediments of the Hanford formation and the Ringold Formation. The aquifer extends from the water table to the top of the basalt or, in some areas, the lower mud (unit 8) of the Ringold Formation. Groundwater flow is to the west-southwest, because the groundwater mound from the 216-B-3 Pond system is diminishing. The average groundwater flow velocities range from approximately 0.01 to 0.04 m/d (0.03 to 0.012 ft/d) (PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*). The water table beneath the Ditch has declined significantly since the discharges to the 216-B-3 Pond system were reduced in 1988 and eliminated by 1995.

The uppermost or unconfined aquifer beneath the 216-B-63 Trench is 3.4 to 6.1 m (11.2 to 20.0 ft) thick and is contained within the sediments of the Hanford formation. The aquifer extends from the water table to the top of the basalt. The Ringold Formation is absent beneath the trench. Groundwater flow has been generally east to west because of the groundwater recharge from the 216-B-3 Pond system, but the hydraulic gradient in this area is changing as the groundwater mound created by the pond system diminishes. Groundwater flow velocity is estimated to range from 0.3 to 0.4 m/d (0.1 to 1.3 ft/d) (PNNL-14187). The water table is nearly flat beneath the trench and has been declining since the discharges to the 216-B-3 Pond system ceased.

The uppermost or unconfined aquifer beneath the 216-S-10 Pond and Ditch is about 61 m (200 ft) thick and is contained within sediments of the Ringold Formation units 4 and 5. The aquifer extends from the water table to the lower mud (unit 8) of the Ringold Formation. Groundwater flow is to the east-southeast at a rate between 0.04 to 2.1 m/d (0.1 and 6.9 ft/d) (PNNL-14187). The water table beneath the pond and ditch has declined significantly since the discharges to the U Pond system ceased in 1984. Additional hydrostratigraphical information may be found in DOE/RL-2002-39, Section 2.1.4.

2.5 NATURAL AND CULTURAL RESOURCES

Natural resources in the study area and vicinity include vegetation and wildlife resources. Biological and ecological information aids in evaluating impacts to the environment from contaminants in the soils, including potential effects of implementing remedial actions and identification of sensitive habitats and species. This section also considers cultural and aesthetic resources and socioeconomics associated with activities in the 200 Areas.

Survey data collected in 2000 and 2001 for the 200 Areas Central Plateau as part of the Ecological Compliance Assessment Project were compiled to support Central Plateau ecological evaluations (DOE/RL-2001-54, *Central Plateau Ecological Evaluation*). The information includes plant-community descriptions, identification of plant and wildlife species, and avian census data. Designated levels of habitat under DOE/RL-96-32, *Hanford Site Biological Resources Management Plan*, including rare-plant populations, are identified and mapped. The data were collected before the 24 Command fire occurred in 2000. The fire, however, did not impact any of the waste sites being considered in this FS.

2.5.1 Vegetation

Vegetation in the study area is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*). The understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*), and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus spp.*), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that also are present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus spp.*), yarrow (*Achillea millefolium*), dwarf evening primrose (*Camissonia pygmaea*), and daisy (*Erigeron spp.*). Dwarf evening primrose is a rare plant and has not been encountered in the study area.

Many of the waste-disposal and storage sites in the 200 Areas have been backfilled with clean soil and planted with crested or Siberian wheatgrass (*Agropyron cristatum* and *Agropyron sibericum*, respectively) to stabilize surface soil, control soil moisture, or displace more invasive deep-rooted species like Russian thistle (PNNL-6415). The area associated with the waste sites addressed in this FS is highly disturbed. This disturbed habitat primarily is the result of mechanical and operational disturbance. Outlying habitats also have been disturbed as a result of range fires, clearing, and construction activities.

2.5.2 Wildlife

The largest mammal frequenting the study area is the mule deer (*Odocoileus hemionus*). Mule deer are much more common along the Columbia River; the few that forage throughout the 200 Areas make up a distinct group called the Central Population (PNNL-11472, *Hanford Site Environmental Report for Calendar Year 1996*). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve and is referred to as the Rattlesnake Hills herd. Elk, which are more dependent on open grasslands for forage, seek the cover of sagebrush and other shrub species during the summer months. The Rattlesnake Hills herd primarily occupies the Arid Lands Ecology Reserve and private lands that adjoin the reserve to the south and west. They occasionally are seen in the 200 Areas and just south of them and have been sighted at the White Bluffs boat launch on the Hanford Site. The herd tends to congregate on the Arid Lands Ecology Reserve in the winter and disperses during the summer months to higher elevations on the Arid Lands Ecology Reserve, private land to the west of the Arid Lands Ecology Reserve, and the Yakima Training Center. In March 2000, about 200 elk were removed from the Arid Lands Ecology Reserve and relocated, and another 31 elk were removed during 2002. Special hunts adjacent to the Hanford Site in 2000 accounted for the removal of 207 additional elk. The 24 Command Fire in June 2000 temporarily destroyed nearly all of the elk forage on the Arid Lands Ecology Reserve. The herd moved onto unburned private land west of the Site, to unburned areas in the center of the Hanford Site, and along the Columbia River near the 100 B/C and 100 K Areas. Elk have returned to burned areas as the vegetation recovers (PNNL-6415).

Experienced biologists reported sighting a cougar (*Felis concolor*) on the Arid Lands Ecology Reserve during the elk relocation in March 2000, supplementing anecdotal accounts of other observations of the presence of a cougar on the Hanford Site (PNNL-6415).

Other mammals common to the 200 Areas are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Areas radioactive waste sites (BNWL-1794, *Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, 200 East Area*). The majority of badger diggings are a result of searches for food, especially for other burrowing mammals such as pocket gophers and mice. Pocket gophers, Great Basin pocket mice, and deer mice are abundant herbivores in the 200 Areas. These small mammals can excavate significant amounts of soil as they construct their burrows ("Disturbance of a Low-Level Waste Burial Site Cover by Pocket Gophers" [Hakonson et al. 1982]). Mammals associated with buildings and facilities include Nuttall's cottontails

(*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the study area include the starling (*Sturnus vulgaris*), horned lark (*Eremophila alpestris*), meadowlark (*Sturnella neglecta*), western kingbird (*Tyrannus verticalis*), rock dove (*Columba livia*), black-billed magpie (*Pica pica*), and raven (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the 200 Areas in abandoned badger or coyote holes, or in open-ended stormwater pipes along roadsides in more industrialized areas. Loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive waste sites.

Reptiles common to the study area include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Rattlesnakes (*Crotalus viridis*) also have been observed. Reptile sightings are not widespread, with only 23 observations of side-blotched lizards at 316 sites surveyed during a 2001 Ecological Compliance Assessment Project survey (DOE/RL-2001-54).

Three of the most common groups of insects include darkling beetles, grasshoppers, and ants. Ants have been known to burrow up to 2.7 m (9 ft) into the vadose zone and to bring contaminants to the surface.

2.5.3 Species of Concern

The Hanford Site is home to a number of species of concern, but many of these are associated with the Columbia River and its shoreline. Two Federally protected species have been observed at the Hanford Site, the Aleutian Canada goose (*Branta canadensis leucopareia*) and the bald eagle (*Haliaeetus leucocephalus*). Both depend on the river corridor and rarely are seen in the Central Plateau. As migratory birds, these species also are protected under the *Migratory Bird Treaty Act of 1918*.

Several threatened, endangered, and candidate species are found in and near the 200 Areas. These species include the ferruginous hawk (*Buteo regalis*), burrowing owl, loggerhead shrike, long-billed curlew, and sage sparrow. Plant species of concern (which include those listed as State endangered, threatened, sensitive, and monitored) that may occur in the study area include dwarf evening primrose and Piper's daisy (*Erigeron piperianus*) (*Washington Rare Plant Species by County* [WNHP 1998]).

Plant and animal species of concern, their designations, and the places of their occurrence can change over time. At this time, it is not anticipated that remediation of the 200-CS-1 OU will affect any species of concern, but incorporating the needs of these species into project planning will help to mitigate any potential effects. Especially important is avoiding, where possible, undisturbed shrub-steppe habitat, because this is important to many species of concern. The undisturbed shrub-steppe in the Central Plateau was designated as Level 3 habitat in DOE/RL-96-32, which requires mitigation of any disturbance (e.g., through avoidance and minimization) and possibly rectification and compensation. More detailed direction on protecting Level 3 habitats and species of concern is provided in DOE/RL-96-32. In addition, site-specific environmental surveys, required before ground disturbance can occur, serve as a final check to ensure that ecological resources are adequately protected.

2.5.4 Cultural Resources

A comprehensive archaeological survey of the 200 Areas found artifacts in conjunction with areas of high topographic relief and in the vicinity of sources of permanent water, but few artifacts associated with open, inland flats (PNL-7264, *Archaeological Survey of the 200 East and 200 West Areas, Hanford Site, Washington*). In the 200 West Area, the only culturally sensitive area identified is the historic White Bluffs Road that crosses the northwest corner of the site. The report concluded that additional cultural resource reviews are required only for proposed projects within 100 m (328 ft) of this road. The waste sites associated with the 200-CS-1 OU are not within 100 m (328 ft) of this road (PNL-7264).

PNL-7264 addressed only undisturbed portions of the 200 Areas and did not address facilities and structures. The *National Historic Preservation Act of 1966* requires agencies to consult with the State Historic Preservation Officer and the Advisory Council on Historic Preservation to ensure that all potentially significant cultural resources, including structures and associated sites, have been adequately identified, evaluated, and considered in planning for a proposed undertaking (e.g., remediation, renovation, or demolition) (DOE/RL-97-56, *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan*).

DOE/RL-97-56 was developed to address these requirements and to determine the eligibility of historic properties for 36 CFR 60, "National Register of Historic Places." DOE/RL-97-56 evaluated and classified waste sites and structures on the Hanford Site, including those in the 200 Areas, and proposed recommendations for mitigation. Treatment options for mitigation were determined using 36 CFR 60.4, "Criteria for Evaluation." None of the waste sites in the 200-CS-1 OU that are subjects of this FS were recommended for individual documentation as contributing properties. Sites beginning with "216" (e.g., 216-A-29 Ditch, 216-S-10 Ditch) were categorized as "noncontributing/exempt properties" (i.e., properties that are exempted from documentation requirements as potential historic sites) (DOE/RL-97-56). Some sites not addressed in DOE/RL-97-56, such as unplanned release and septic tanks that were not considered to be significant enough to be evaluated as part of that activity, will be evaluated under site-specific preremediation cultural-resource reviews.

No cultural resources have been directly associated with OU waste sites (PNL-7264; DOE/RL-97-56; PNNL-6415); however, site-specific cultural-resource reviews will be required for each waste site before remediation or other ground-disturbing activities are begun. In addition to the site-specific review, a cursory field review of plant and animal life may be conducted in concert with this activity.

2.5.5 Aesthetics, Visual Resources, and Noise

With the exception of Rattlesnake Mountain, land on the Hanford Site generally is flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,478 ft) above mean sea level, forms the southwestern boundary of the Hanford Site, and Gable Mountain and Gable Butte are the highest landforms on the Hanford Site itself. The view toward Rattlesnake Mountain is visually pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and far north. The Columbia River, flowing across the northern part of the Site and forming the eastern boundary, generally is considered scenic.

Studies at the Hanford Site on the propagation of noise have been concerned primarily with occupational noise at work sites. Environmental noise levels have not been extensively evaluated because of the remoteness of most Hanford Site activities and their isolation from receptors covered by Federal or State statutes. Most industrial facilities on the Hanford Site are located far enough away from the Site boundary that noise levels at the boundary are not measurable or are indistinguishable from background noise levels (PNNL-6415).

2.5.6 Socioeconomics

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities and other parts of Benton and Franklin counties. The agricultural community also has a significant effect on the local economy. Any major changes in Hanford Site activity potentially would affect the Tri-Cities (Richland, Pasco, Kennewick, and smaller surrounding communities) and other areas of Benton and Franklin Counties. Unless otherwise specifically cited, data in this section are collected from interviews with the referenced organization.

The Hanford Site is the largest single source of employment in the Tri-Cities. During fiscal year 2002, an average of 10,892 employees were employed by the DOE - Office of River Protection and its prime contractor CH2M HILL Hanford Group, Inc.; RL and its prime contractor Fluor Hanford, Inc.; Battelle Memorial Institute; Bechtel Hanford, Inc.; and the Hanford Environmental Health Foundation. The fiscal year 2002 year-end employment at the Hanford Site was 10,938, up from 10,670 in fiscal year 2001. In addition to these totals, Bechtel National, Inc., and its prime subcontractor, Washington Group International, employed 3,013 at the end of fiscal year 2002, up from 1,350 at the end of fiscal year 2001. In December 2000, the Office of River Protection awarded a contract to Bechtel National, Inc., to design, build, and start up waste treatment facilities for the glassification of liquid radioactive waste. According to the State of Washington Labor Market and Economic Analysis, the annual average number of employees at the Hanford Site is down considerably from a peak of 19,200 in fiscal year 1994, but still represents 15 percent of the 94,000 total jobs in the economy.

In addition to the Hanford Site, other key employers in the area are as follows:

- Energy Northwest
- The agricultural community (including the ConAgra food processing plants)

- Iowa Beef Processing
- Areva NP Inc. – Advanced Nuclear Products (formerly Framatome ANP and Siemens, Inc.)
- Boise Cascade Corporation, Paper and Corrugated Container Divisions
- Burlington Northern and Santa Fe Railroads.

Tourism and government transfer payments to retirees in the form of pension benefits also are important contributors to the local economy.

An estimated total of 147,600 people lived in Benton County and 51,300 lived in Franklin County during 2002, for a total of 198,900, which is up almost 4 percent from 2000. According to the 2000 Census, population totals for Benton and Franklin Counties were 142,475 and 49,347, respectively. Both Benton and Franklin counties grew at a faster pace than Washington as a whole in the 1990s. The population of Benton County grew 26.6 percent, up from 112,560 in 1990. The population of Franklin County grew 31.7 percent, up from 37,473 in 1990 (*Poverty Thresholds in 2000, by Size of Family and Number of Related Children Under 18 Years* [U.S. Bureau of the Census 2001]).

Based on the 2000 Census, the 80 km (50-mi) radius area surrounding the Hanford Site had a total population of 482,300 and a minority population of 178,500. PNNL-6415 shows the total population "within" 80 km as 511,500, which was estimated by a Geographical Information System from the populations of individual census block groups, the smallest geographic area for which both minority and poverty status were estimated in the 2000 Census. The higher number resulted because the total population of a census block group previously was assigned to the 80 km area if *any part* of the block group lay within 80 km of the Hanford Meteorological Station in the middle of the Hanford Site. The new estimate splits boundary block groups to include only those portions within 80 km, which should result in a lower and more accurate estimate. The ethnic composition of the minority population is primarily White Hispanic (24 percent), self-designated "other and multiple" races (63 percent), and Native American (6 percent). Asians and Pacific Islanders (4 percent) and African American (3 percent) make up the rest. The Hispanic population resides predominantly in Franklin, Yakima, Grant, and Adams counties. Native Americans within the 80 km (50 mi) area reside primarily on the Yakama Reservation and upstream of the Hanford Site near the town of Beverly, Washington. PNNL-6415 provides maps showing distributions of minority and low-income populations.

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Figure 2-1. Application of the Analogous Site Approach.

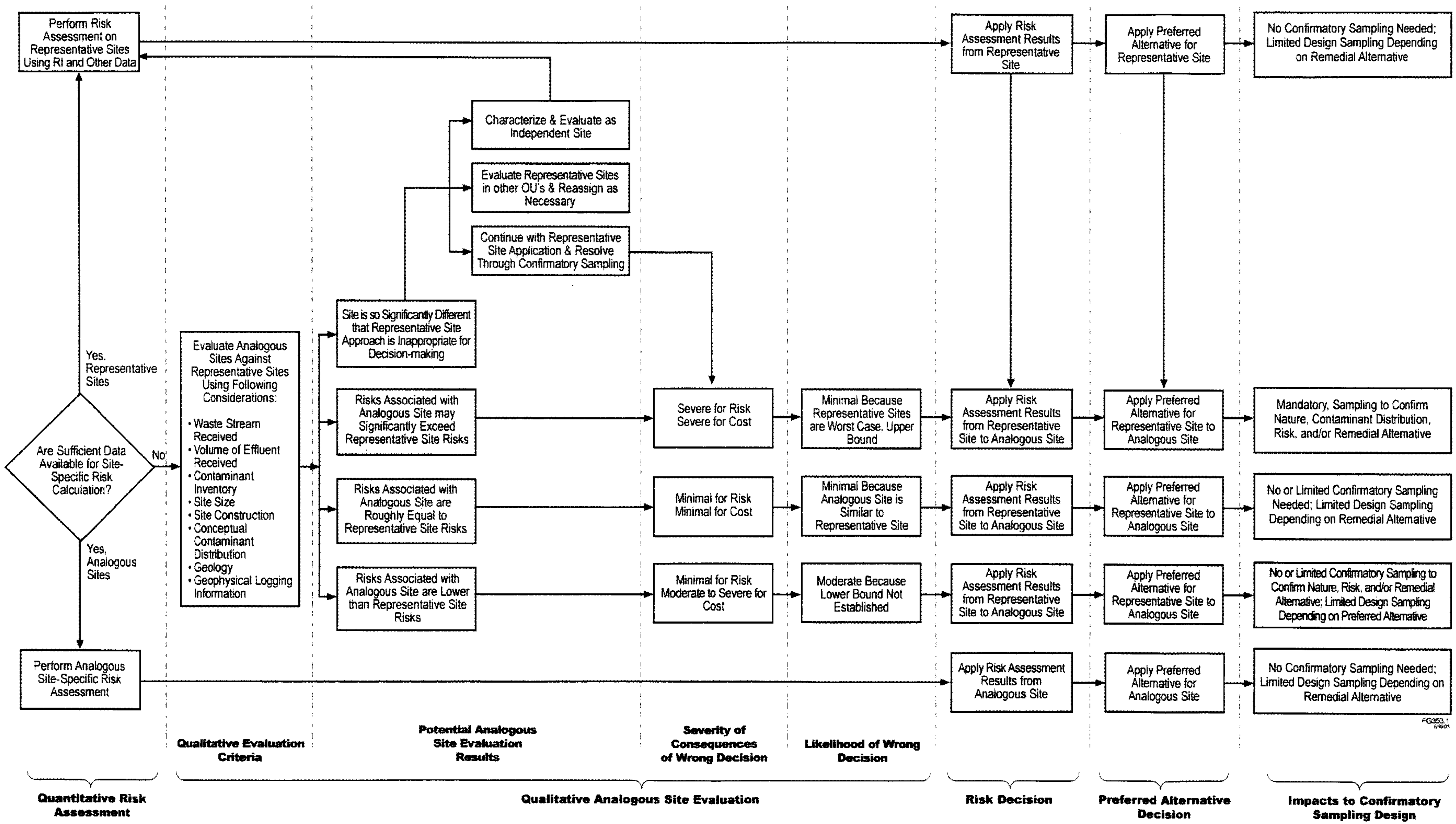

Figure 2-2. 216-A-29 Ditch Borehole and Test Pit Locations.

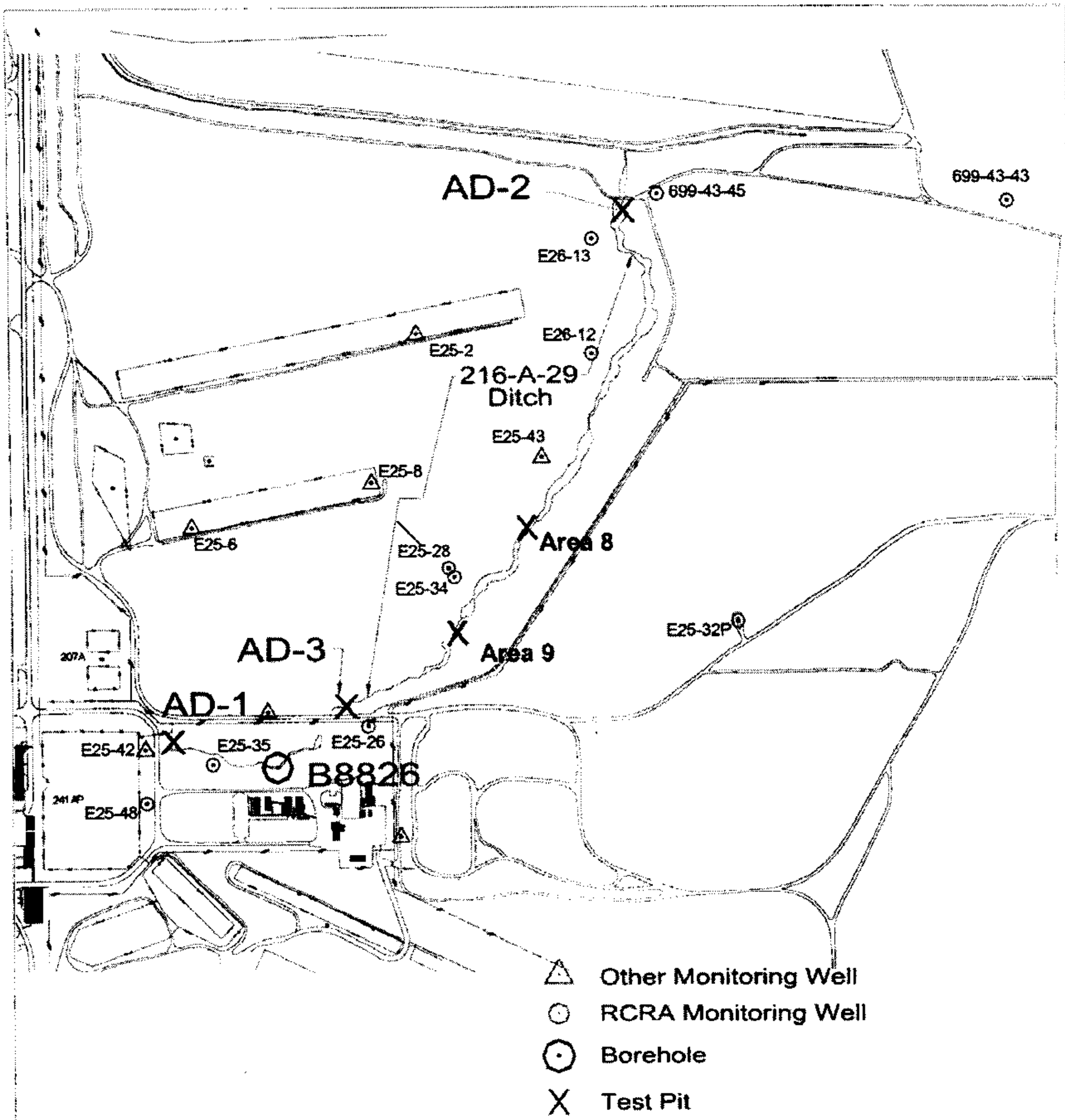

Figure 2-3. 216-B-63 Trench Borehole and Test Pit Locations.

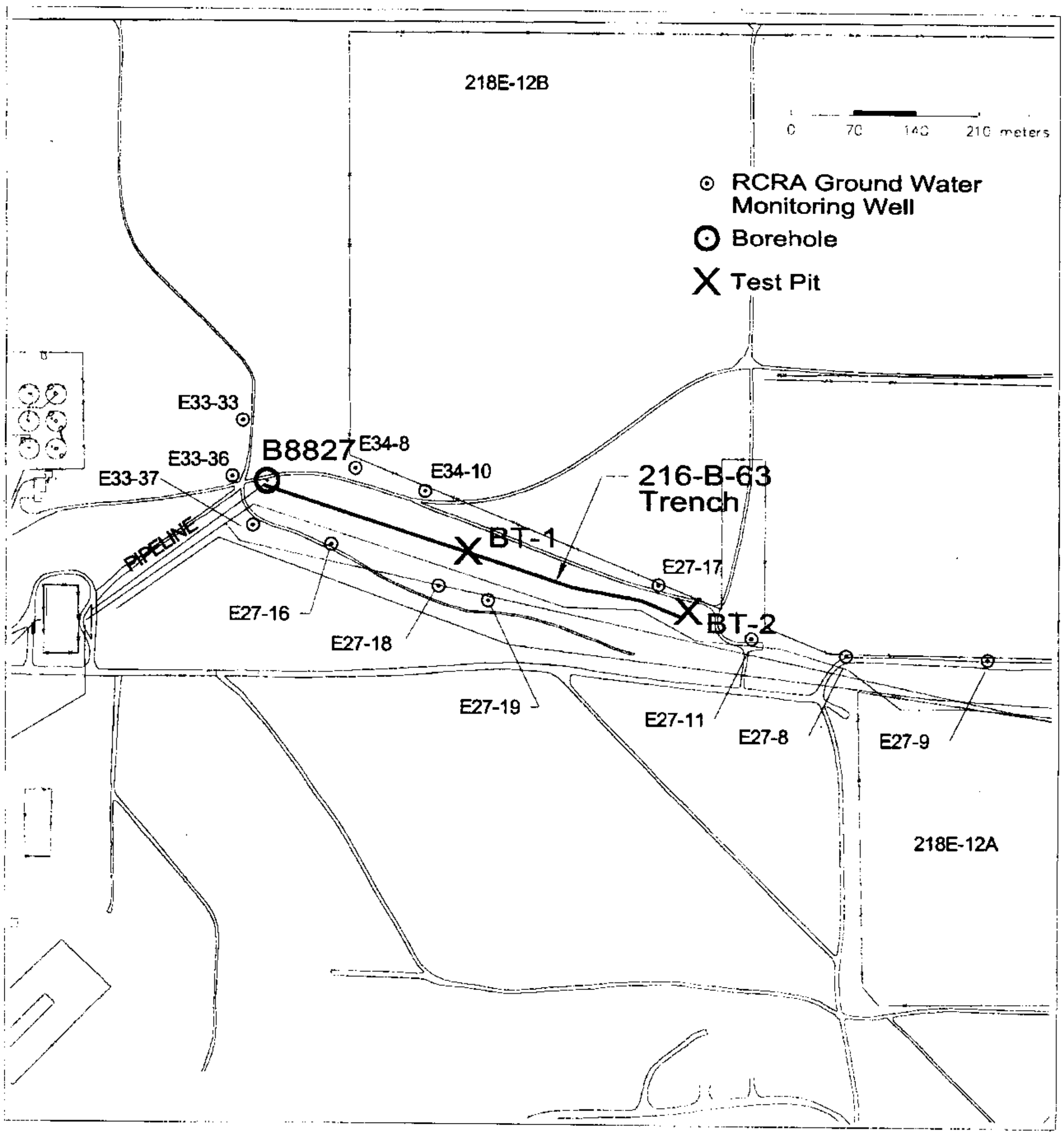

Figure 2-4. 216-S-10 Ditch and Pond Borehole and Test Pit Locations.

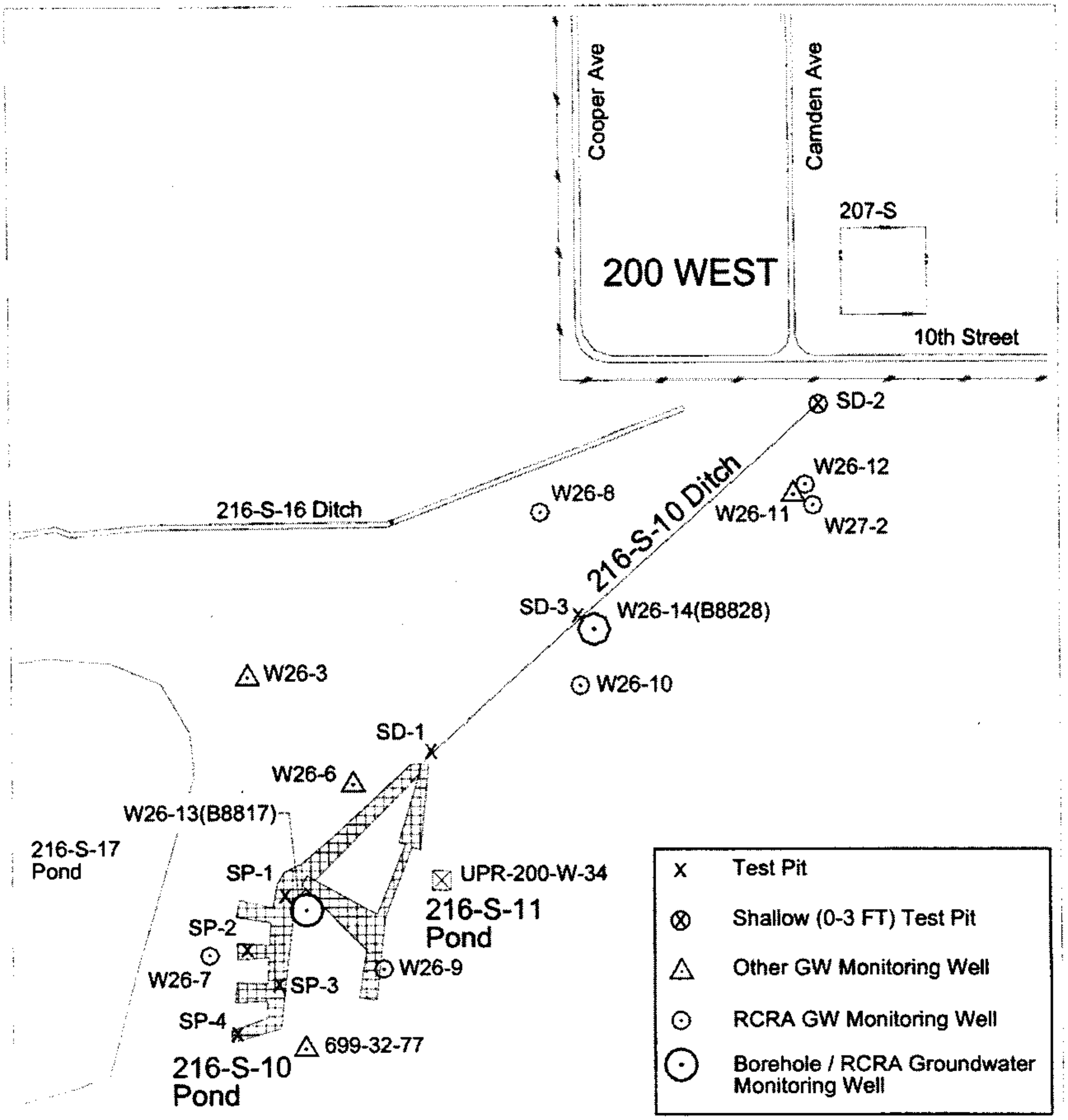

Figure 2-5. Stratigraphic Column for the 200 Areas

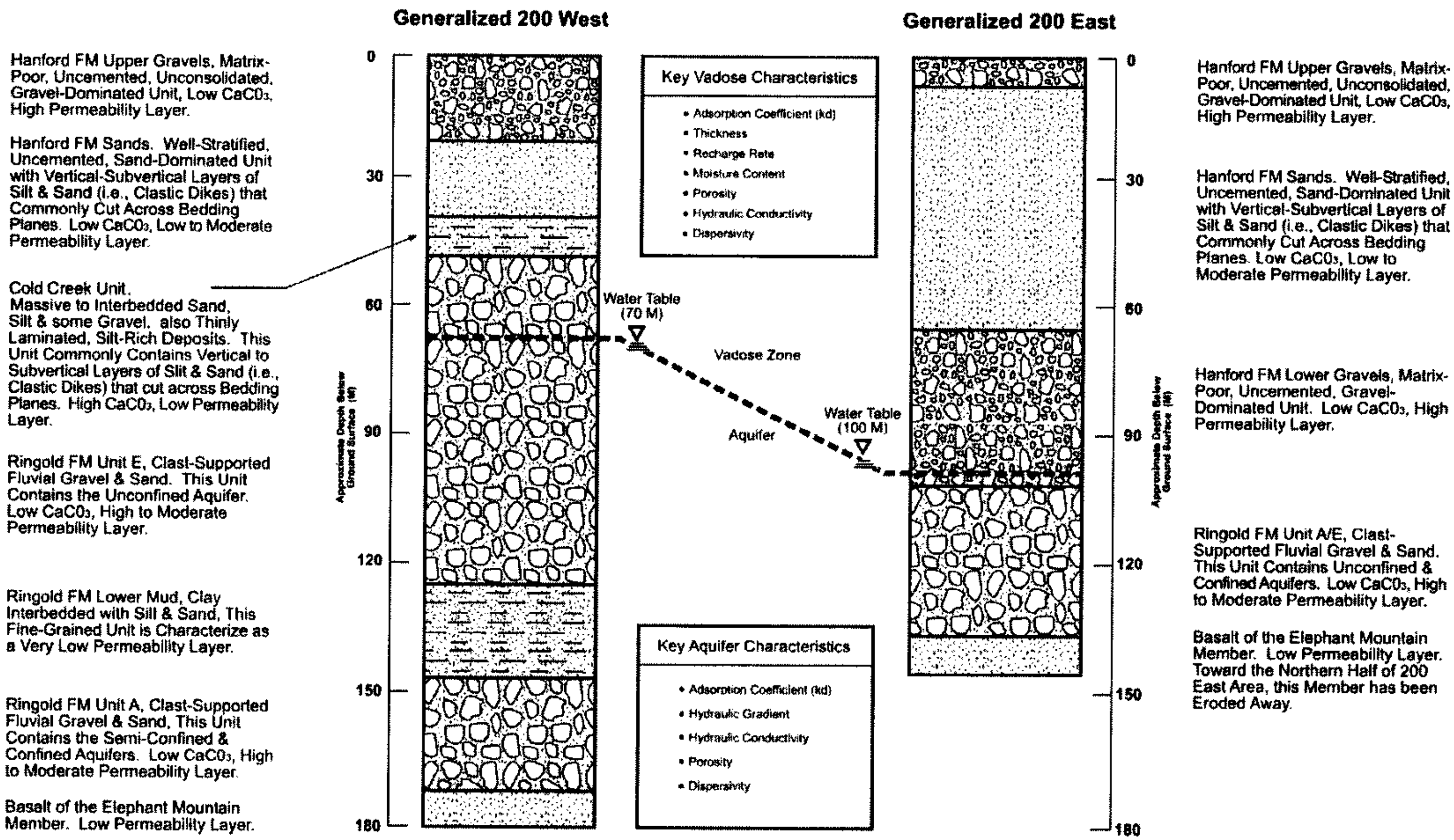

Figure 2-6. Geologic Cross Section Through the 216-A-29 Ditch.

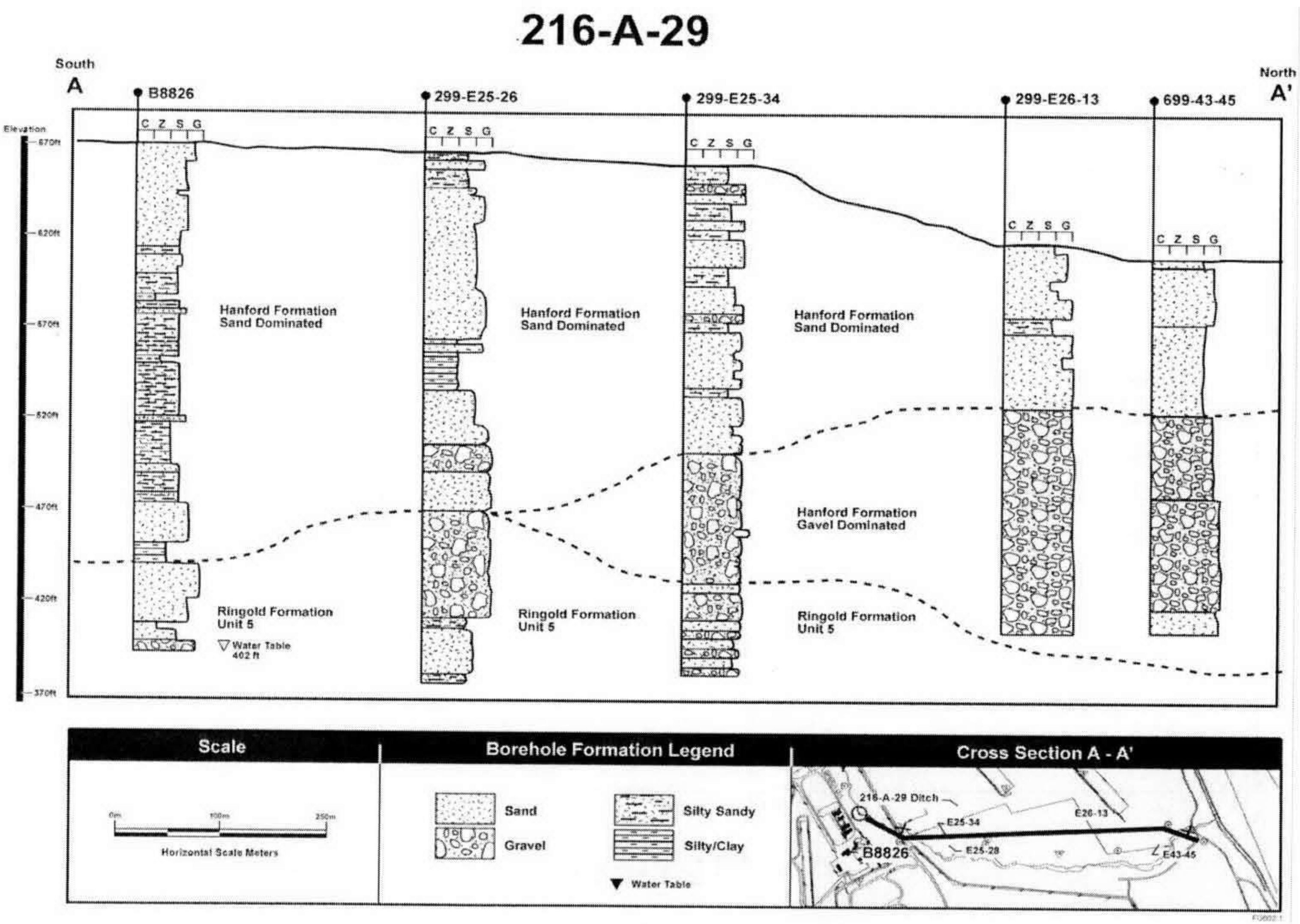

Figure 2-7. Geological Cross Section Through the 216-B-63 Trench.

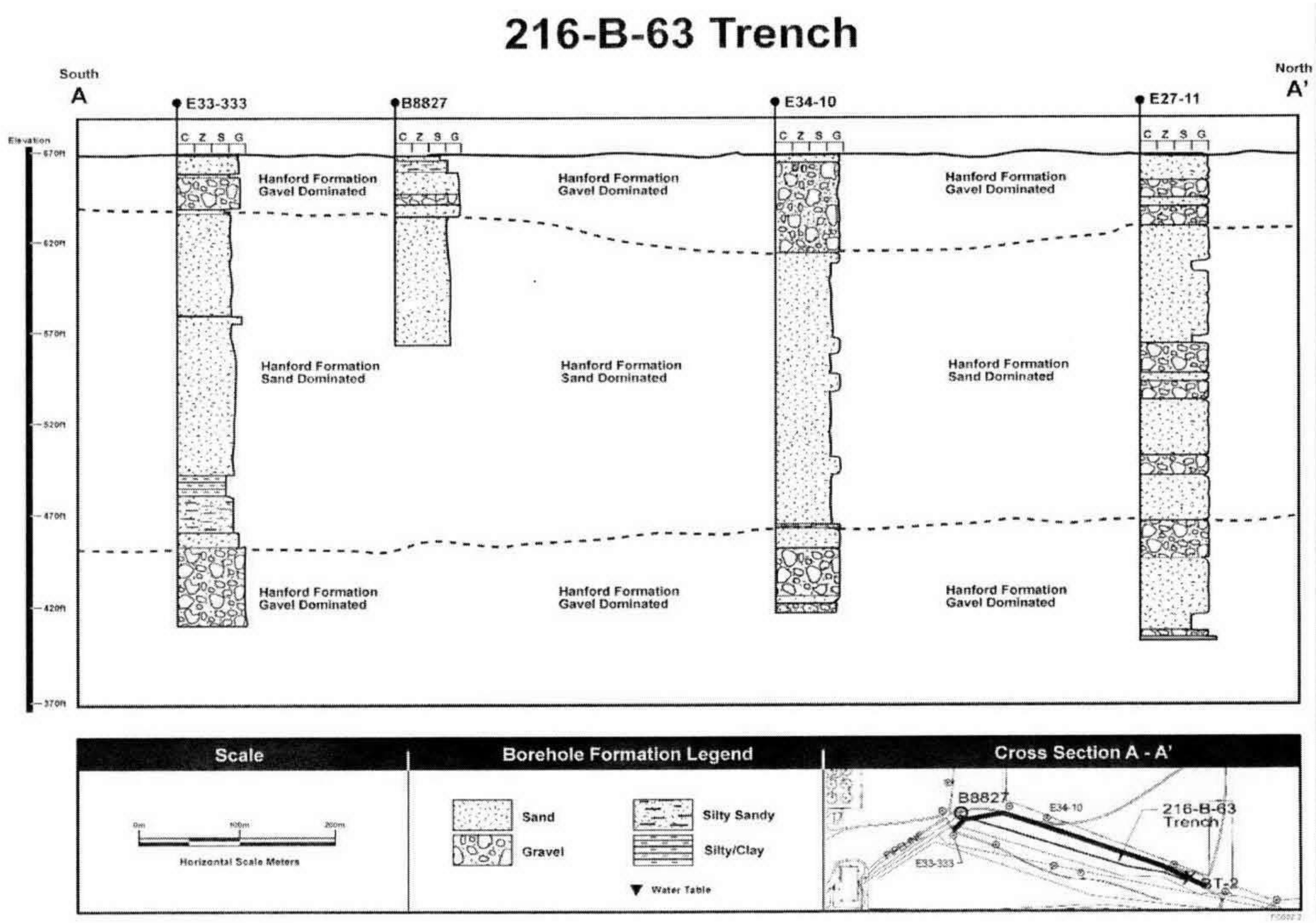

Figure 2-8. Hydrogeologic Cross Section at the 216-S-10 Pond and Ditch.

(From PNNL-14070, Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch)

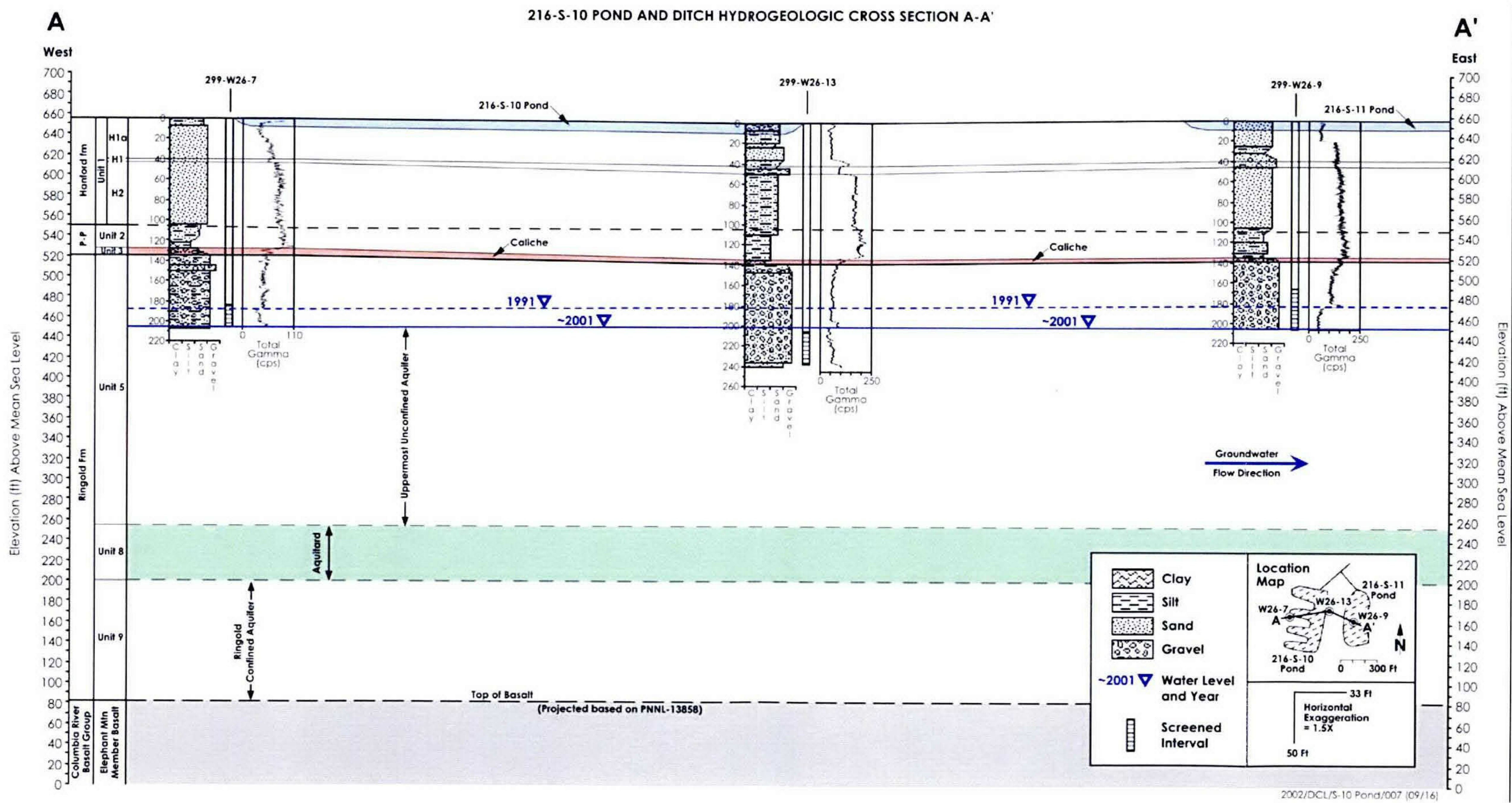

Table 2-1. Partial Inventory of Chemicals Released to the 216-A-29 Ditch Between 1983 and 1987.

Chemicals	Kilograms	Pounds
Aluminum nitrate nonahydrate	8,379	18,455
Ammonium fluoride	2,437	5,368
Ammonium nitrate	461	1,016
Cadmium Nitrate	39	85
Ferrous sulfamate	43	95
Hydrazine	290	639
Hydroxylamine nitrate	316	695
Nitric Acid	18,952	41,745
Potassium hydroxide	66,208	145,833
Potassium permanganate	4,858	10,700
Sodium carbonate	641	1,412
Sodium Hydroxide	20,993	46,240
Sodium nitrate	73	160
Sodium nitrite	579	1,275
Sulfamic Acid	91	200
Sulfuric Acid	1,887	4,156

Modified from DOE/RL-99-44, *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan.*

Table 2-2. Lithofacies of the Cold Creek Unit.

Lithofacies	Environment of Deposition	Previous Site Nomenclature
Fine-grained, laminated to massive. Consists of a brown- to yellow very well sorted cohesive, compact, and massive- to laminated- and stratified-fine-grained sand and silt. It is moderately to strongly calcareous with relatively high natural background gamma activity.	Fluvial-overbank and eolian	Palouse soil, early "Palouse" soil, Hanford formation/ Plio-Pleistocene unit silt.
Fine- to coarse-grained, calcium carbonate cemented. Consists of basaltic to quartzite gravels, sands, silts, and clay that are cemented with one or more layers of secondary, pedogenic calcium carbonate.	Calcic paleosol	Highly weathered subunit of the Plio-Pleistocene unit/ caliche, calcrete.
Coarse-grained, multilithic. Consists of rounded, quartzose to gneissic clast-supported pebble- to cobble-size gravel with a quartzo-feldspathic sand matrix.	Mainstream alluvium	Distantly derived subunit of the Plio-Pleistocene unit/ pre-Missoula flood gravel.
Coarse-grained, angular, basaltic. Consists of angular, clast- to matrix-supported basaltic gravel in a poorly sorted mixture of sand and silt with no stratification. Calcic paleosols may be present.	Colluvium	New facies designation for the Pasco Basin.
Coarse-grained, round basaltic lithofacies.	Sidestream alluvium	Locally derived subunit of the Plio-Pleistocene unit.

Based on DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin.*

3.0 BASELINE RISK ASSESSMENT

The evaluation of risk at a hazardous waste site is an important component in the remediation process. "Because the RI/FS is an analytical process designed to support risk management decision-making for Superfund sites, the assessment of health and environmental risks plays an essential role in the RI/FS" (EPA/540/G-89/004). Uncertainties associated with the assessment of risk to human health and the environment, as well as the evaluation of remedial options "...can be numerous, ranging from potential unknowns regarding site hydrogeology and the actual extent of contamination, to the performance of treatment and engineering controls being considered as part of the remedial strategy. While these uncertainties foster a natural desire to want to know more, this desire competes with the Superfund program's mandate to perform cleanups within designated schedules. The objective of the RI/FS process is not the unobtainable goal of removing *all* uncertainty, but rather to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site" (EPA/540/G-89/004). As part of the assessment of health and environmental risk, the level of uncertainty associated with a number of factors considered during the assessment is identified and discussed.

A BRA was performed as one of the objectives of the RI Report (DOE/RL-2004-17). The initial RI BRA concluded that the data collected during the RI were of sufficient quantity and quality to support the risk-assessment activities and to proceed to the FS to support evaluation of remedial alternatives and identify preferred remedial actions in the FS. An evaluation of the groundwater-protection pathway indicated that contaminants currently in the vadose zone likely would impact groundwater in the future, but were not likely to increase groundwater concentrations above current levels. The RI BRA identified risks associated with the observed levels of chemical and radionuclide contamination at the site. However, some uncertainties associated with the degree and extent of contamination were not clearly defined and discussed in the RI and presented some challenges to developing the FS alternatives.

The uncertainty analysis plays a key role in understanding the implications for the remedy and devising post-ROD strategies to achieve a safe, effective, and efficient remedy. In the process of evaluating the RI BRA's ability to support the draft FS, it was discovered that some sample results inadvertently were missed that qualified for inclusion in the BRA under both CERCLA and *Washington Administrative Code* guidance. These data, if used, may have affected the extent and degree of contamination evaluated at the 200-CS-1 OU sites and, in turn, would have influenced risk-level determinations and the areas and volume of wastes addressed in the FS. As a result, DOE decided to proceed with a revision to the BRA with an expanded uncertainty discussion, to be included with this FS.

The revised BRA presented in Chapter 3.0 is organized in the following manner.

- Section 3.1 provides an overview; summarizes the original characterization strategy; and presents the rationale, scope, and objectives for the revised BRA.

- Section 3.2 summarizes the conceptual site model, including potential exposure routes and receptors, and summarizes land and groundwater use at the site.
- Section 3.3 summarizes the data used for this revised BRA and describes the initial data evaluation steps used to select contaminants of potential concern (COPC) and contaminants of potential ecological concern (COPEC).
- Section 3.4 presents the human-health risk assessment.
- Section 3.5 presents the ecological risk assessment.
- Section 3.6 presents an evaluation of the groundwater-protection pathway.
- Section 3.7 summarizes the three risk assessments (i.e., human health, ecological, and groundwater-protection pathway) and overall uncertainties. This section also discusses implications for the FS.

3.1 BASELINE RISK ASSESSMENT OVERVIEW

The EPA defines a BRA as "…an analysis of the potential adverse health effects (current or future) caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases (i.e., under an assumption of no action)" (EPA/540/1-89/002). The BRA characterizes current site conditions and contamination in the absence of any remedial action that might reduce potential risks in the present or future. Although some action has been taken in the past to backfill and stabilize the waste sites in the 200-CS-1 OU, RI characterization data are based on current conditions. As a result, the risk assessments completed in this chapter are referred to as BRAs, which is consistent with EPA terminology. The purpose of the BRA is to (1) evaluate potential risk at a site and determine the primary causes of that risk, (2) help determine whether remediation response actions are necessary, and (3) help modify cleanup levels (or support a "no-action" alternative when appropriate). The results of the BRA and the FS are to be used by the risk manager of a site to provide information to the decision-making process. The BRA should present the available site data, methodologies followed, identified risks, and associated uncertainties in a clear, logical, easy-to-understand, and transparent manner.

In general, the BRA completed in the RI Report and the revised BRA completed for this FS follow EPA risk-assessment guidance (EPA/540/1-89/002; EPA/540/R-97/006, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Interim Final)*; and Ecology guidance in WAC 173-340). The approach used includes the following:

- Adherence to CERCLA and *Washington Administrative Code* guidance for a human-health risk assessment, a screening-level ecologic risk assessment (SLERA), and an analysis of the groundwater-protection pathway

- Inclusion of all samples from locations at or near the waste sites (within 30.5 m [100 ft] of the waste site)
- Use of maximum concentrations in all scenario calculations
- Selection of conservative parameters to avoid false-negative risk determinations.

In addition to human-health and ecological risk assessments, potential threats to groundwater under the 200-CS-1 OU are evaluated. In this report, this analysis is referred to as the "groundwater-protection pathway" and is used to evaluate potential impacts to groundwater from infiltration of radionuclides and nonradionuclide chemicals in contaminated soil to the aquifer. The approach used, combined with the original sampling survey design, more likely results in an over-estimation of risk and possible over-specification of the selected remedy. This was recognized in the original RI/FS strategy (documented in DOE/RL-99-44) and was anticipated that the uncertainties arising from the RI sampling design would be resolved with additional sampling in the remedial design/remedial action phase.

The following section describes the original sampling strategy, the methodology adopted to use these data in the BRA, and how the results and uncertainties can be addressed in post-ROD activities.

3.1.1 Sampling Strategy, Data Usability, and Uncertainty

The purpose of the Work Plan (DOE/RL-99-44) was to establish the methods and criteria for the RI sampling, analysis, characterization, and evaluation. The Work Plan for the 200-CS-1 OU documents that the sampling design was intentionally biased to identify worst case conditions/maximum concentrations. It also states that the primary goal of the field sampling was to characterize the site and document potential impacts to groundwater. Because of the prior application of cover/fill material at the site, surface-soil samples were not collected for the purpose of estimating the potential for direct contact exposure to contaminants by human and ecological receptors. This biased sampling approach is critical to understanding and defining the level of uncertainty in site characterization and in the subsequent use of the data in the BRA.

The Work Plan outlined a nonstatistical sampling design was to be conducted and acknowledged that the consequence of this biased sampling approach was not considered severe (DOE/RL-99-44). The Work Plan indicated that the biases and uncertainties arising from the site characterization would be resolved with additional sampling in the remedial design/remedial action phase.

While the use of biased sampling results in a risk assessment also biases the potential risks, the small number of sample locations and small sample sizes can also be a source of uncertainty. EPA mandates that Superfund cleanups occur within designated schedules, with the goal of gathering sufficient data to support an informed risk-management decision about the most appropriate remedy. This requires that the biases inherent in a biased sampling design, and the uncertainty associated with small sample sizes, be accommodated in the risk analyses and clearly presented in the uncertainty discussion. In this manner, risk managers can address these uncertainties and determine the need for additional characterization and assessments in the remedial design/remedial action phase.

The data used for the revised BRA were collected under the Work Plan, based on the DQOs established for this OU in BHI-01276. In accordance with the quality assurance/quality control (QA/QC) procedures specified in the Work Plan, at least 10 percent of all data were validated, and a data quality assessment was performed. The data quality assessment is summarized in Appendix A of the RI Report (DOE/RL-2004-17). No sample results were rejected based on this assessment.

In addition to outlining characterization strategy and sampling protocols, the Work Plan provides a preliminary list of COPCs for the 200-CS-1 OU, which includes all contaminants that were potentially discharged to the chemical sewer OU waste sites. A list of contaminants to be evaluated in the RI, BRA, and FS was developed from this list of COPCs, based on specific exclusion criteria described in the DQO document (BHI-01276). Additional data for a number of contaminants not on the contaminants of concern (COC) list in the Work Plan were provided in the data set used for the BRA. The raw data used for this revised BRA are provided in Appendix A of this document.

3.1.2 Scope and Objectives of the Revised Baseline Risk Assessment

This risk assessment was conducted to determine whether a potential for risk to human health and the environment exists under current and reasonably anticipated future site-use conditions at the 200-CS-1 OU. The results are used, in part, to focus the scope of the FS and determine whether remedial action should be further evaluated or required.

The scope of the revised risk assessment follows EPA and *Washington Administrative Code* guidance and conducts baseline risk assessments for the four representative waste sites (the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and 216-S-10 Pond) in the 200-CS-1 OU. The exposure area (or exposure unit) evaluated in the BRA is the ditch, trench, or pond itself at each of these sites. A human-health risk assessment, a SLERA, and an analysis of the groundwater-protection pathway are completed for each waste site in the revised BRA. Radiological and nonradiological constituents measured in shallow-zone soils (i.e., 0 to 4.6 m [0 to 15 ft] bgs) are evaluated for potential human-health and ecological impacts. An analysis of the groundwater-protection pathway is conducted for contaminants measured in the entire soil column (i.e., 0 m to approximately 76 m [250 ft] bgs).

As identified by DOE, groundwater use by humans is precluded for the foreseeable future, and is not observed in the shallow-soil zone where ecological receptors may contact groundwater. As a result, the use of groundwater by human or ecological receptors is not evaluated as a potential exposure pathway for these waste sites. Remediation of contaminated groundwater beneath the Central Plateau is the subject of the RI/FS activities under way for the 200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1 Groundwater OUs.

The main objectives of the risk assessments presented in this FS are to achieve the following:

- Logically present the methodology used and describe the various steps of each assessment
- Identify nonradionuclide and radionuclide COCs, based on their potential for presenting unacceptable health and environmental risks
- Clearly present the inherent uncertainties associated with the available data; assumptions and parameters used for exposure, toxicity, and contaminant fate and transport; and the resulting risk outcome, for use in the analysis of remedial alternatives.

3.2 CONCEPTUAL MODEL

A key component of a BRA is the formulation of a conceptual model for the site. The conceptual model identifies all potential sources, contaminant-release mechanisms, environmental transport media, potential exposure points, potential exposure routes, and potential receptors. Site history, physical setting, and current and future land and groundwater use are important factors used to develop the conceptual model. This section describes the conceptual model for the site.

The physical settings and histories of the 200-CS-1 OU waste sites are described in detail in Chapter 2.0 of this FS. In summary, the primary sources of contamination at the 200-CS-1 OU were major facilities (e.g., PUREX Plant, B Plant, and REDOX facility) that routinely discharged low-level contaminated chemical-sewer wastewater to unlined ponds and ditches and where unplanned releases periodically occurred. Waste inventories for the 200-CS-1 OU waste sites are not well documented. Some inventory information exists for total plutonium and uranium, Am-241, Cs-137, and Sr-90 (DOE/RL-96-81). With the exception of the 216-S-10/11 Ditch and Pond system waste sites, where more than 215 kg of uranium were reportedly discharged, only very low levels of fission products and plutonium and small quantities of uranium are known to exist at the 200-CS-1 OU waste sites.

Downward migration of the wastewater through the vadose zone occurred while the waste sites were in use. Most of the contaminants were retained by the sediments at the bottom of the liquid-waste disposal sites. Lateral spreading may have occurred in the vadose zone, especially in areas with layers of fine-grained sediment or in facilities that received a large amount of effluent. According to the applicable aggregate area management study reports, effluent that percolated through the vadose zone beneath the waste sites was hypothesized to have reached groundwater.

3.2.1 Land Use

The DOE worked for several years with cooperating agencies and stakeholders to define land-use goals for the Hanford Site and to develop future land-use plans (*The Future for Hanford:*

Uses and Cleanup, The Final Report of the Hanford Future Site Uses Working Group [Drummond 1992]). Cooperating agencies and stakeholders included the National Park Service, Tribal Nations, the States of Washington and Oregon, local county and city governments, economic and business development interests, environmental groups, and agricultural interests. These activities initially were reported by Drummond (1992) and culminated in the DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*, and 64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)," which were issued in 1999.

Based on DOE/EIS-0222-F and the associated ROD (64 FR 61615), industrial (exclusive) land use is defined as "preserving DOE control of the continuing remediation activities and use of the existing compatible infrastructure required to support activities such as dangerous waste, radioactive waste, and mixed waste treatment, storage, and disposal facilities" (DOE/EIS-0222-F). The 216-B-63 Trench, 216-A-29 Ditch waste sites, 216-S-10 Pond, 216-S-10 Ditch and the 216-S-11 Pond are located in the Core Zone consistent with the Tri-Parties' response (Klein et al., 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area") to Hanford Advisory Board (HAB) Advice #132 (HAB 132, "Exposure Scenarios Task Force on the 200 Area"). That document indicates that this area of the Site will have an "Industrial Scenario" for the foreseeable future. As a result, the industrial land-use scenario is considered for all of the 200-CS-1 waste sites in the revised BRA..

In addition to the industrial land-use scenario, three unrestricted land-use scenarios (i.e., rural residential-, intruder-, and Tribal-use scenarios) are evaluated in Appendix B to provide decision makers with information on potential human-health and ecological risks associated with a variety of potential land uses.

3.2.2 Groundwater Use

Under both current and future conditions, no complete human- or ecological-exposure pathways to groundwater are assumed at these waste sites. Local groundwater is not a current source of drinking water at the 200-CS-1 OU waste sites and, regardless of the land-use designation for soil, groundwater beneath the waste sites is not anticipated to become a future source of drinking water until groundwater cleanup criteria are met and groundwater is restored to the highest beneficial use (i.e., drinking-water purposes).

Direct exposure to groundwater by terrestrial receptors is considered an incomplete exposure pathway, because no groundwater connection to the surface is available. In addition, the aquifer is too deep for plant roots to bring groundwater contaminants from the aquifer to the surface of the sites.

Remediation of contaminated groundwater beneath the Central Plateau is the subject of the RI/FS activities under way for the 200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1 Groundwater OUs and is not included in the scope of this BRA and FS.

3.2.3 Points of Compliance

WAC 173-340-745(7), "Soil Cleanup Standards for Industrial Properties," establishes a point of compliance for soil-cleanup levels based on potential human exposure to soils via direct contact. This point of compliance is established for soils from the ground surface to 4.6 m (15 ft) bgs. This is intended to represent a reasonable estimate of the depth of soil that could be excavated and distributed at the soil surface, resulting in the potential for human and ecological receptors to contact soil contaminants. In compliance with WAC 173-340-745(7), the BRA assumes that human and ecological receptors have the potential to contact shallow-zone soils from the ground surface to a depth of 4.6 m (15 ft) bgs.

In contrast to evaluating the direct-contact exposure pathway for human and ecological receptors, the groundwater-protection pathway is used to assess potential impacts to groundwater related to infiltration of water and subsequent leaching of radionuclides and nonradionuclide chemicals from contaminated soil to the aquifer. The entire vadose zone is considered for this pathway because of the impact of infiltration of water through contaminated vadose-zone soils on groundwater. This analysis assumes that the groundwater is the point of compliance.

3.2.4 Exposure Pathways

Exposure to site contaminants can occur when contaminants migrate from the source to an exposure point or when a receptor comes into direct contact with contaminated media. The conceptual model describes potential exposure pathways by identifying potential exposure points, potential exposure routes, and potential receptors. An exposure pathway is complete if the receptors can intake contaminants through ingestion, inhalation, direct exposure, or dermal absorption at a location where site-related contaminants are present. No exposure (and therefore no risk) exists unless the exposure pathway is complete.

3.2.4.1 Human-Health Exposure Pathways

The exposure pathways for potential current and future human receptors at the 200-CS-1 OU have been formulated based on the site conceptual model, in accordance with standards provided in specific sections of EPA and WAC 173-340 guidance. Because the land use of the four waste sites is considered industrial (exclusive) (DOE/EIS-0222-F), the most probable human receptor is an industrial worker, and the exposure point is direct soil contact.

As shown in Figure 3-1, all potentially complete human-exposure pathways are associated with exposure to shallow-zone soils (WAC 173-340-745(7)). Complete exposure pathways considered for the industrial land-use scenario include incidental soil ingestion and inhalation (radionuclides and nonradionuclides), dermal absorption (nonradionuclides only), and external irradiation (radionuclides only).

3.2.4.2 Ecological Exposure Pathways

The conceptual model for ecological exposures is provided in Figure 3-2. Consistent with the conceptual site model in DOE/RL-2001-54, the exposure pathways expected to be complete at the 200-CS-1 OU waste sites are the following:

- Direct contact with, or ingestion of, soil by invertebrates (e.g., beetles, ants)
- Uptake of contaminants in soil by vegetation
- Direct contact with, or ingestion of, soil by burrowing mammals
- Bioaccumulation through ingestion of food items consumed by wildlife that may forage at the waste sites.

This model provides a current understanding of the sources of contamination, physical setting, ecological habitat, receptors of concern, and current and future land use, and identifies potentially complete ecological-exposure pathways for the study area. Information generated during the RI process has been incorporated into this conceptual site model to identify potential exposure scenarios. The conceptual site model addresses exposures that could result under current site conditions and from reasonably anticipated potential future uses for the site and the surrounding areas.

3.3 SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

COPCs are chemicals or radionuclides that are present in the environment at levels that may place exposed humans at risk for experiencing adverse health effects and may partially or wholly originate from site-related sources. COPECs are chemicals or radionuclides that are present at levels that may be unsafe for ecological receptors. To identify COPCs and COPECs at the 200-CS-1 OU, a stepwise selection process described by the EPA and *Washington Administrative Code* guidance (EPA/540/1-89/002; EPA/540/R-97/006; WAC 173-340) was used.

3.3.1 Data Summary

The data collected for the RI (and other surveys) and used for this risk assessment were extracted from the *Hanford Environmental Information System* (HEIS) database. The RI data originally were validated in a data quality assessment review provided in Appendix A of the RI Report (DOE/RL-2004-17). This section provides a broad summary of the analytical data. Appendix C provides a detailed summary and presents the minimum and maximum detected and nondetected concentrations for all analytes, as well as the detection frequency, by waste site.

Within each waste site, 4 to 6 locations were sampled, with 2 to 31 samples were collected from varying depths at each location. Across all waste sites and depths, 177 samples were collected (including field duplicates and splits). Ninety-one of these samples were collected from shallow-zone soils (0 m to 4.6 m [15 ft]), while 86 samples came from deep-zone soils (4.6 m [15 ft] to groundwater).

Each sample was analyzed for inorganic chemicals (including metals), organic chemicals, and radionuclides. In all, 42 inorganic chemicals, 131 organic chemicals, and 52 radionuclides (in addition to gross alpha and gross beta radiation counts) were analyzed. However, analytical constituents varied across sample location and depth. Appendix C contains a detailed summary of all of the nonradionuclide and radionuclide data. In general, most of the inorganic chemicals were detected in at least one sample for all waste sites. In both shallow- and deep-zone soils, few organic chemicals were detected. Of the organic chemicals that were analyzed, only about 5 percent to 20 percent were detected in at least one sample. Different from both the inorganic and organic chemicals, about half of all radionuclides analyzed were detected in at least one sample.

3.3.2 Data Evaluation

The data evaluation steps used in identifying COPCs/COPECs at the 200-CS-1 OU include the following: (1) identification of detected constituents, (2) comparison of shallow-zone and deep-zone soils to Hanford Site background levels, (3) elimination of essential nutrients, and (4) certain analytical considerations. COPCs/COPECs were identified separately for shallow-zone soils for the human and ecological receptors, and COPCs were identified for shallow- and deep-zone soils combined for the groundwater-protection pathway.

3.3.2.1 Step 1: Identification of Detected Constituents

As illustrated in Figure 3-3, the HEIS database was queried, and the data were filtered and grouped to identify the maximum detected concentration per analyte for each waste site, by shallow- and deep-zone soils. Rejected results (i.e., qualified with an "R") were excluded from the data-evaluation process and were not used because they indicate, based on laboratory information or through the data quality assessment process, that a specific sample or result should not be used for decision making purposes. All nonradiological and radiological constituents detected in one or more samples were included in the human-health and ecological risk assessments and the groundwater-protection pathway analysis. Maximum detected results were selected for use in all cases.

Sample data with estimated concentrations (i.e., those qualified with a "J," indicating that the result is an estimate) were evaluated at their reported concentrations. The data for some analytes were qualified to indicate that those analytes were detected in associated laboratory blanks (i.e., those qualified with a "B"). These data were evaluated at their reported concentrations. However, if a maximum concentration potentially was affected by laboratory-blank contamination, it was taken into account when discussing implications for the FS.

All constituents that were detected at least once in any of the shallow- or deep-zone soil samples were retained. Constituents that were not detected in any of the soil samples (i.e., 0 percent frequency of detection) were not evaluated further. Appendix C shows all analytes, including those with 0 percent frequency of detection.

3.3.2.2 Step 2: Comparison to Hanford Site Background Concentrations

Some chemicals have a wide range of occurrence in soil and water. Detecting these chemicals at a site does not necessarily indicate that they were introduced by site releases. EPA/540/R-01/003, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, OSWER 9285.7-41) defines background constituents as (1) *anthropogenic* - natural and human-made substances present in the environment as a result of human activities (i.e., their presence at the site is not specifically related to the CERCLA release in question), and (2) *naturally occurring* - substances present in the environment in forms that have not been influenced by human activity.

Lognormal 90th percentile background values for the Hanford Site (representative of both naturally occurring and anthropogenic substances) were used in the background-concentration comparison for inorganic chemicals and radionuclides. Background values for inorganic chemicals are identified in DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Summary Table 2. Radionuclide background values are identified in DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, Table 5-1. Three types of background sampling were conducted. Both systematic random sampling and judgmental sampling were conducted for inorganic chemicals and naturally occurring radionuclides; surface sampling was conducted for anthropogenic radionuclides. The composition of background samples described in DOE/RL-92-24 and DOE/RL-96-12 is representative of the sedimentary facies in the vadose zone at the 200-CS-1 OU sites. These background data are recommended for use in environmental-restoration activities on the Hanford Site to maintain consistency between projects, and they have been peer reviewed for technical credibility.

DOE/RL-92-24 recommends using the systematic random-sampling results as the primary data set for inorganics. If the analyte does not have sufficient random-sampling background data (or is not different from random-sampling background results), then the judgmental sampling should be used as a secondary data set. For naturally occurring radionuclides, the systematic random-sampling background data are recommended as the primary data set. For anthropogenic radionuclides, the surface-sampling background data are recommended as the primary data set. Some inorganics and radionuclides did not have reported 90th percentile background values in Table 2 or Table 5-1 of the two DOE reports, respectively. In these cases, other sources were researched. In addition to the DOE reports, background information also was obtained from Ecology 94-115, *Natural Background Soil Metals Concentrations in Washington State*.

Table 3-1 shows the background values and data sources used for this step. Table 3-1 also includes other distributional parameters of the systematic random-sampling data set. The lognormal 90th percentile first was used to compare the site maximum value. If the maximum concentration was greater than the 90th percentile background value, the constituent was carried forward to the following step in the COPCs/COPECs selection process. However, if the site maximum value was only slightly greater than the 90th percentile background concentration, additional parameters were reviewed: the lognormal 95th percentile and the 90 percent upper confidence limit. These parameters better illustrate the distribution of background results. Although WAC 173-340-709, "Methods for Defining Background Concentrations," recommends that lognormal 90th percentile background values be used to compare site data to background results when alternative statistical methods are not employed, the EPA prefers the use of statistical comparisons (or upper confidence limit values) when evaluating background and site data (EPA/540/1-89/002).

A background value for uranium as an inorganic contaminant (not a radionuclide) is unavailable in DOE/RL-92-24, as noted in Table 3-1. The background value for inorganic uranium, used for comparison purposes, was derived by dividing the 90th percentile background activity levels for U-234, U-235, and U-238 by the specific activity for each isotope, converting those values from picocuries per gram to milligrams per kilogram, and then summing the calculated values for each isotope to arrive at a total background value (letter, "RE: Background Value Question" [Hoover, 2007]).

Any inorganic chemicals or radionuclides that do not have background values reported in DOE/RL-92-24, DOE/RL-96-12, or other described sources were carried forward to the next step of the COPC/COPEC identification process. Because background criteria have not been developed for organic chemicals in Hanford Site soils, these constituents were passed through to the next steps of the evaluation process. Constituents with maximum concentrations less than their respective 90th percentile background value were not selected as COPCs/COPECs.

3.3.2.3 Step 3: Essential-Nutrient Screening

Essential nutrients are those constituents considered essential for human nutrition. Recommended daily allowances are developed for essential nutrients to estimate safe and adequate daily dietary intakes (NAS 1989, *Recommended Dietary Allowances*). Essential nutrients for wildlife evaluated in the ecological risk assessment are similar to those identified in the human-health risk assessment.

Examples of essential nutrients for human health are described in EPA/540/1-89/002 and include iron, magnesium, calcium, potassium, and sodium. To ensure that site concentrations of essential nutrients are not significantly elevated above background levels, these analytes were compared to their background concentrations. However, essential nutrients generally are not evaluated in a risk assessment (EPA/540/1-89/002). All essential nutrients were eliminated as human-health COPCs, because they were not greater than background concentrations, except calcium at 216-A-29 Ditch. The maximum concentration of calcium at this waste site is greater than the 95th percentile background by 19 percent and is not considered to be significantly elevated above background because it is less than the recommended daily intake.

Essential nutrients for wildlife evaluated in the ecological risk assessment are similar to those identified in the human-health risk assessment. Because site concentrations are only slightly higher than background, the essential nutrients of calcium, potassium, and sodium also are not considered in the ecological risk assessment. Other essential nutrients that do have published ecological risk-based criteria were advanced to the next step, because they can be toxic following exposures to moderately elevated concentrations, such as copper, selenium, and zinc.

3.3.2.4 Step 4: Data Considerations

The following provisions were made for the specific analytes discussed below.

- Total beta radiostrontium and Sr-90. Sample results were reported as either Sr-90 or total beta radiostrontium. When total beta radiostrontium is reported, it consists primarily of Sr-90 (half-life 29 years) and Sr-89 (half-life 55 days). For the purposes of this risk assessment, all total beta radiostrontium was considered to be in the form of Sr-90.

- Nitrite, nitrate, and nitrate/nitrite as N. Total nitrogen in nitrate and nitrite results (referred to as nitrate/nitrite as N) were provided in addition to total nitrate and total nitrite concentrations. The nitrate/nitrite as N concentration is the total of the nitrogen in both nitrate and nitrite. Because criteria exist for total nitrate, as well as nitrate as N and nitrite as N, and no criterion exists for nitrate/nitrite as N, the nitrate/nitrite as N results were not evaluated.

- Benzo(g,h,i)perylene, phenanthrene, and Aroclor 1260.[1] If a toxicity value was not available from the EPA's *Integrated Risk Information System* (IRIS) database, the *Provisional Peer Reviewed Toxicity Values* database (EPA, not available to the general public), or other acceptable source, then a surrogate toxicity value for a structurally similar chemical was used. Toxicity values were not available for benzo(g,h,i)perylene, phenanthrene, and Aroclor 1260. Pyrene was selected as a surrogate for benzo(g,h,i)perylene, and the cleanup level for pyrene was used in place of a benzo(g,h,i)perylene cleanup level in the risk assessment. Anthracene was selected as a surrogate for phenanthrene, and the cleanup level for anthracene was used in place of a phenanthrene in the risk assessment. The cleanup level for polychlorinated biphenyls was used for Aroclor 1260.

3.3.3 Contaminants of Potential Concern

Upon completion of the data evaluation phase described above, the COPCs/COPECs were carried forward into their respective risk assessment. COPCs and COPECs are described in each risk assessment presented below. Section 3.4 presents the human-health risk assessment, Section 3.5 presents the SLERA, and Section 3.6 presents the analysis of the groundwater-protection pathway.

[1] Aroclor is an expired trademark.

3.4 HUMAN-HEALTH RISK ASSESSMENT

The baseline human-health risk assessment evaluates potential adverse health effects in the absence of any remedial action. The risk-assessment approach for the human-health industrial scenario is illustrated in Figure 3-4. In the first phase of the risk assessment, COPCs were identified on the basis of criteria described in Section 3.3. The COPCs then are evaluated in the risk-assessment phase, as shown in Figure 3-4. Potential risks are evaluated for nonradionuclides by following WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties" guidance, and radionuclides are characterized following EPA guidance (EPA/540/1-89/002). The results of the human-health risk evaluation are presented below, and the associated uncertainty discussion is presented in Sections 3.4.3 and 3.7.

Before the nonradionuclide and radionuclide risk-assessment discussions below, it should be noted that the exposure-point concentrations used for both nonradionuclides and radionuclides at these waste sites are the detected maximum concentrations. A 95 percent upper confidence limit on an average concentration generally is the recommended approach to estimate an exposure-point concentration for the reasonable maximum exposure (RME) expected to occur at a site (*Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER 9285.6-10 [EPA 2002]; and EPA /540/1-89/002). However, because of the biased sampling strategy, the relatively small number of independent sample locations, and the small number of detected results (typically less than 50 percent for nearly all analytes), the use of a maximum concentration is more appropriate for this OU. Most analytes have either 0, 1, or 2 detected results, with the exception of some metals and radionuclides. The few independent sample locations create uncertainty in the representativeness of the data, especially for the deep-zone soils to groundwater where only one borehole was sampled. In addition, the Work Plan stated that because of the few sample locations, the maximum detected concentration would be used as the exposure point concentration (DOE/RL-99-44). The average concentration generally is used as the exposure-point concentration for the central tendency exposure expected to occur at the site. However, for the same reasons mentioned above, no average concentration was calculated, and the maximum detected value in the 0 to 4.6 m (0 to 15 ft) soil column, referred to as shallow-zone soil, at each waste site is evaluated as the RME. EPA guidance warrants the use of the RME scenario as the basis for alternative evaluation in the FS (memorandum, "Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions" [Clay 1991]).

3.4.1 Nonradionuclide Risk Assessment

WAC 173-340 mandates that site cleanups protect the state's citizens and the environment. Ecology has established standards for hazardous waste sites to implement this statutory mandate. This has resulted in cleanup levels to ensure that unacceptable risks are not posed to human health and the environment. For an industrial human-health scenario, the unacceptable risk level is 10^{-5} for carcinogens and a hazard quotient greater than one for noncarcinogens. The WAC 173-340 approach was used to complete the nonradionuclide risk assessment for the 200-CS-1 OU waste sites (as shown in Figure 3-4).

WAC 173-340 established cleanup standards and requirements, and Ecology has published an online database that contains precalculated cleanup levels for a large number of chemicals, based on the unacceptable risk levels stated above. Cleanup levels integrate toxicological and exposure information. The subsequent comparison of the maximum concentrations for COPCs to the established cleanup levels is considered the risk-assessment phase for nonradionuclides.

3.4.1.1 WAC 173-340-745 Human-Health Cleanup Levels

The industrial land-use direct soil exposure Method C cleanup levels (WAC 173-340-745(5), "Method C Industrial Soil Cleanup Levels") presented in the *Cleanup Levels & Risk Calculations (CLARC)* database (Ecology 2005) are precalculated and were downloaded from the CLARC online database (https://fortress.wa.gov/ecy/clarc/CLARCHome.aspx) on February 6, 2007, as documented in Appendix F. Toxicological information and exposure assumptions are used to develop the precalculated WAC 173-340-745 cleanup levels.

The purpose of the toxicity information is to identify the potential adverse health effects associated with exposure to contaminants and to estimate the likelihood that these adverse health effects may occur based on the extent of exposure, using the numerical toxicity values. For nonradioactive chemicals, two general types of health effects are evaluated: cancer effects and adverse noncancer health effects. This distinction is made because the EPA generally assumes that a dose threshold exists for noncarcinogens and that compensatory biological processes prevent the expression of adverse health effects if humans are exposed to chemical doses below the threshold. No such threshold generally is assumed for carcinogens. Instead, it generally is assumed that a finite probability of developing cancer is associated with any exposure to a carcinogen. As a result, carcinogens and noncarcinogens have separate toxicity criteria, called slope factors and reference doses, respectively, and are explained further in Appendix D. In general, the toxicological effects of a compound are the dominant health effects of the chemical, as determined by the EPA. The reference doses and slope factors are contained in the CLARC database.

Exposure factors are those factors that define the exposure pathway, such as exposure duration and frequency, soil ingestion, and air-inhalation rates. WAC 173-340-745 contains exposure factors used to calculate the risk-based cleanup levels. These factors are summarized in Table 3-2 and in the equations listed below. Exposure factors used to develop cleanup levels are considered representative of reasonable maximum exposure under industrial land-use conditions.

The following equations describe the information used to establish the cleanup levels reported in the CLARC database. If a cleanup level was not reported in the CLARC database, it was calculated in accordance with equations in WAC 173-340-900, "Tables," Table 745-1 and Table 745-2. Tributyl phosphate was the only chemical not reported in CLARC, and a cleanup level was calculated. The equations are as follows.

For noncarcinogens (equation 745-1):

$$CUL = (RfD \times ABW \times UCF \times HQ \times AT)/(SIR \times AB1 \times EF \times ED)$$

where:

CUL	=	cleanup level for soil (mg/kg)
RfD	=	reference Dose as specified in WAC 173-340-708(7) (mg/kg-day)
ABW	=	average body weight over exposure duration (70 kg)
UCF	=	unit conversion factor (1,000,000 mg/kg)
HQ	=	hazard quotient (1) (unitless)
AT	=	averaging time (20 years)
SIR	=	soil ingestion rate (50 mg/day)
AB1	=	gastrointestinal absorption fraction (1.0) (unitless)
EF	=	exposure frequency (0.4) (unitless)
ED	=	exposure duration (20 years).

For carcinogens (equation 745-2):

$$CUL = (Risk \times ABW \times AT \times UCF)/(CPF \times SIR \times AB1 \times ED \times EF)$$

where:

CUL	=	cleanup level for soil (mg/kg)
Risk	=	acceptable cancer risk level (1 in 100,000 or 10^{-5}) (unitless)
ABW	=	average body weight over exposure duration (70 kg)
AT	=	averaging time (75 years)
UCF	=	unit conversion factor (1,000,000 mg/kg)
CPF	=	carcinogenic Potency Factor (also referred to as Slope Factor) as specified in WAC 173-340-708(8)[2] (kg-day/mg)
SIR	=	soil ingestion rate (50 mg/day)
AB1	=	gastrointestinal absorption fraction (1.0) (unitless)
ED	=	exposure duration (20 years)
EF	=	exposure frequency (0.4) (unitless).

3.4.1.2 Comparison to Washington Administrative Code Cleanup Levels

The COPCs identified in the data-evaluation phase are compared to the cleanup levels for each representative waste site and are presented in Tables 3-3a through 3-3d. The COPCs are those chemicals that either did not have a background concentration or were greater than

[2] WAC 173-340-708(8), "Human Health Risk Assessment Procedures," "Carcinogenic Potency Factor."

background concentrations and, if greater than background, were not considered an essential nutrient. The only essential nutrient slightly greater than the background 90th and 95th percentiles was calcium at the 216-A-29 Ditch (Table 3-3a). This essential nutrient meets the EPA exclusion criteria (EPA/540/1-89/002), because it is only slightly greater than the 95th percentile background concentration (no more than 20 percent) and is not considered a COPC.

As seen in Tables 3-3a through 3-3d, the industrial land-use direct soil exposure Method C cleanup levels (WAC 173-340-745(5)) reported in the CLARC database were used to compare to the maximum concentrations of nonradiological COPCs. For lead and total petroleum hydrocarbons, the Method A cleanup levels were used (WAC 173-340-745(3), "Method A Industrial Soil Cleanup Levels"). When a COPC is considered both a carcinogen and a noncarcinogen, the lower of the two cleanup levels provided in CLARC was selected for comparison purposes.

Exposure routes and exposure factors are considered in conjunction with other chemical-specific toxicity information to calculate risk-based cleanup levels as described above. Some constituents do not have enough toxicological information available to calculate risk-based cleanup levels. In some cases, surrogate or other compounds from the same class were used for those analytes with no risk-based cleanup levels. For example, phenanthrene and benzo(g,h,i)perylene, both polycyclic aromatic hydrocarbons (PAH), do not have established toxicity levels and therefore no established cleanup levels. As a result, other PAH risk-based cleanup levels were examined and compared to the detected site concentrations (as discussed in Section 3.3.2.4, pyrene is used as a surrogate for benzo(g,h,i)perylene, and anthracene was used as a surrogate for phenanthrene).

Constituents in this category for which an appropriate surrogate could not be identified are considered qualitative COPCs and are not evaluated further. These COPCs are not considered risk drivers, and exceedance factors (i.e., a ratio of the site concentration to the cleanup level) cannot be calculated.

3.4.1.3 Nonradionuclide Contaminants of Concern

A COPC with a maximum concentration that was not greater than the corresponding industrial cleanup level was not considered a COC. All other constituents (maximum concentrations greater than the cleanup levels) were considered COCs under the industrial land-use direct soil-exposure scenario. If a constituent did not have established toxicity levels and therefore had no established cleanup levels, and a surrogate risk-based cleanup level could not be identified, then that contaminant is considered a qualitative COPC and is discussed in the uncertainty analysis in Section 3.4.3, and any known toxicological information is summarized in Appendix D.

No COCs were identified because the COPCs were either less than the CUL or did not have accepted toxicity values for establishing a CUL. The results of this assessment are shown in Tables 3-2a through 3-3d.

3.4.2 Radionuclide Risk Assessment

Radionuclide risk assessment closely follows the EPA approach of identifying COPCs, completing exposure and toxicity assessments, and integrating that information into risk characterization and discussing uncertainty, as outlined in EPA/540/1-89/002. Human-health risk assessment for radionuclides is consistent with the conceptual site model described in Section 3.2 and shown in Figure 3-1.

Risk assessment for radionuclides was accomplished using the RESRAD code Version 6.3 (ANL, 2005, *RESRAD*, Version 6.3, at: http://web.ead.anl.gov/resrad/register2/). EPA evaluated the suitability of over two dozen multimedia pathway models and computer codes for analysis of radionuclide cleanup sites. Three models met the majority of the evaluation criteria; RESRAD version 5.19 was identified as one of the three models (EPA/402/R-96/011-A, *Radiation Site Cleanup Regulations: Technical Support Document for the Development of Radionuclide Cleanup Levels for Soils*). EPA evaluated the codes for their ability to model the transport of a contaminant via an exposure pathway, including defining (1) the nature, extent, and location of the contaminant source or sources, (2) actual or potential mechanisms of release, migration, and fate in the environment, (3) a medium or media through which the contaminant is transported or in which the contaminant remains, (4) points of possible receptor contact with the contaminated medium, and (5) an exposure route (e.g., ingestion). These criteria are consistent with the important elements of the analyses to be performed to support this FS.

RESRAD Version 6.3 was used to estimate the annual dose and the excess lifetime cancer risk. The analysis proceeds in two steps. First, the results of soil characterization in shallow-zone soils are used to construct a simplified model of radionuclide distributions in the soil at each site. The soil model specifies the concentration of various radionuclides in the shallow-zone soils at the 200-CS-1 OU waste sites. In this simplified approach, the soil contamination is assumed to be present in layers below the ground surface, each layer having a uniform concentration of the contaminants. Second, the soil model is input to the RESRAD software to calculate potential human-health risks from the contamination.

The annual radiation doses and excess lifetime cancer risks are calculated for various time periods. For comparative purposes, radiation dose and risk estimates are discussed relative to the following exposure times.

- 0 year represents current waste-site conditions.
- 50 years is the estimated time that DOE will have an on-site presence.
- 150 years is the estimated time that ICs are assumed to be effective.
- 500 years is the estimated time that passive ICs are assumed to be effective.
- 1,000 years is the estimated time frame that peak radiation dose and risk estimates should fall within.

- The year in which the target radiation dose limit of 15 mrem/y is achieved.

Radionuclide COPCs, assumptions, input parameters, and model results for potential human-health risks based on RESRAD modeling are discussed below. Appendix E contains the details of the RESRAD analysis.

3.4.2.1 Radionuclide Contaminants of Potential Concern

Table 3-4 presents the comparison of site maximum radioactivity compared to background concentrations to identify COPCs.

Those radionuclide COPCs that are greater than background are evaluated through RESRAD modeling (ANL, 2005). The RESRAD model uses toxicological information, radioactive decay information, and exposure factors to calculate annual dose rates and total lifetime excess cancer risk. The integration of that information is considered risk characterization and is discussed below.

3.4.2.2 Toxicity Assessment of Contaminants of Potential Concern

The purpose of a toxicity assessment is to identify the potential adverse health effects associated with exposure to site COPCs and to estimate the likelihood that these adverse health effects may occur based on the extent of exposure, using numerical toxicity values. RESRAD contains the necessary toxicological information, so no additional toxicological research was performed. Cancer-risk estimates in RESRAD employ cancer-risk morbidity slope factors from EPA-SAB-RAC-99-009, *An SAB Report: Review of Health Risks from Low-Level Environmental Exposure to Radionuclides (FGR-13 Report).*

In general, radiation-induced health effects can be classified as stochastic (i.e., cancer health effects) or nonstochastic (i.e., acute noncancer health effects). Unlike stochastic effects, nonstochastic effects are characterized by a threshold dose below which they do not occur. Nonstochastic effects have a clear relationship between the exposure and the effect. In other words, the magnitude of the effect is directly proportional to the size of the dose. Nonstochastic effects typically result when extremely large doses of radiation are received in a short amount of time. Examples of nonstochastic effects include skin and tissue burns, cataract formation, sterility, radiation sickness, and death. Examples of stochastic health effects include carcinogenesis, mutagenesis, teratogenesis, and life shortening.

Several references (*Health Effects of Exposure to Low Levels of Ionizing Radiation [BEIR V]* [NRC, 1990]; EPA/540/1-89/002) provide risk factors for these effects. However, the Committee on the Biological Effects of Ionizing Radiation (BEIR V) considers that limiting exposure to reduce cancer risk also limits genetically significant exposure (NRC, 1990). Superfund risk-assessment guidance states that the risk of cancer appears to be limiting and may be used as the sole basis for assessing the radiation-related human-health risk of a site contaminated with radionuclides (EPA/520/1-89/005, *Risk Assessment Methodology: Environmental Impact Statement for NESHAPS Radionuclides, Vol. I: Background Information Document*). In general, it is recommended that only carcinogenic effects be routinely evaluated for radionuclides, because carcinogenesis is the predominant adverse human-health effect. Some exceptions may occur (e.g., the nephrotoxic effects of uranium) and will be evaluated on a case-by-case basis. As a result of the dose-response relationships for radionuclides, the EPA states that a toxicity assessment for individual radionuclides need not be addressed in detail (EPA/540/1-89/002).

3.4.2.3 Radionuclide Exposure Factors

Exposure factors are those factors that define the exposure pathway, such as exposure duration and frequency, and soil ingestion and air-inhalation rates. The various parameters to represent the exposure pathways initially were provided in EPA/540/R-92/003, *Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual.* These have been updated in EPA/600/P-95/002Fa, *Exposure Factors Handbook,* and EPA-540/R-00/006, *Soil Screening Guidance for Radionuclides: Technical Background Document.*

Under an industrial/commercial land-use scenario, the site owner permits limited use of the land directly over the waste sites. Any facilities constructed would be single-story and would have footing depths no more than 0.6 m (2 ft). Because all of the 200-CS-1 OU waste sites have a cover depth at least 0.6 m (2 ft) thick, there is no intrusion into the contaminated soil layer near the surface.

The worker is exposed to the buried waste daily during a normal work year (250 days per year) for a total of 25 years. Exposure pathways include (1) direct exposure to penetrating photon radiation, (2) inhalation of dust particulates that become airborne, and (3) incidental ingestion of trace amounts of soil. Because the buried waste is not brought to the surface, the only complete exposure pathway is from direct exposure to gamma radiation that penetrates the cover soil. The internal pathways (inhalation and ingestion) are considered incomplete and result in zero dose. Appendix E provides a detailed discussion on the RESRAD modeling and the rationale for those incomplete pathways.

More detail about the exposure factors used in the RESRAD analysis are provided in Section E6.1 and summarized in Table E-18 of Appendix E. Note that the industrial scenario includes no drinking-water pathways. The worker is present onsite during the work week, but any drinking or wash water is brought in from elsewhere. This is part of the anticipated future land use of the Hanford Site.

3.4.2.4 Risk Characterization

Risk characterization is the final phase of a human-health risk assessment. EPA describes this phase as the point in the risk assessment at which "...the toxicity and exposure assessments are summarized and integrated into quantitative and qualitative expressions of risk. To characterize potential noncarcinogenic effects, comparisons are made between projected intakes of substances and toxicity values; to characterize potential carcinogenic effects, probabilities that an individual will develop cancer over a lifetime of exposure are estimated from projected intakes and chemical-specific dose-response information. Major assumptions, scientific judgments, and to the extent possible, estimates of the uncertainties embodied in the assessment are also presented" (EPA/540/1-89/002).

For radionuclides, the integration of toxicological information, radioactive-decay information, and exposure factors to calculate annual dose rates and total lifetime excess cancer risk using the RESRAD code is considered risk characterization.

3.4.2.4.1 RESRAD Assumptions and Input Parameters

Waste site-specific or Hanford Site-specific data were used where available as input parameters for the RESRAD modeling. The specific parameter values and associated rationale and references for each RESRAD input parameter are provided in Appendix E.

Specific input radionuclide concentrations for the shallow-zone soils are summarized in Table 3-4. No radioactive decay of the sample results is assumed when inputting initial concentrations (considering that the samples were collected between 1999 and 2003, approximately 4 to 8 years of possible decay has occurred). The sample data include a number of radionuclides that are naturally occurring in soil. These naturally occurring radionuclides are K-40, U-238 with progeny, U-235 with progeny, and Th-232 with progeny. The radionuclides with short half-lives are not input to RESRAD. Short half-life progeny also are not input to RESRAD, because it accounts for these by using decay chains and assumes that they quickly come to equilibrium with the long-lived parent nuclides.

3.4.2.4.2 RESRAD Results

Dose and risk for each exposure pathway and radionuclide are summed to calculate the total dose or total risk to an individual. Table 3-5 summarizes the estimated dose and excess lifetime cancer risk for each of the four waste sites. No human-health dose or risk criteria are surpassed for the 216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and 216-S-10 Pond. As described above, the worker is not exposed to contaminated soil, so no dose is received through the inhalation and ingestion pathways, and the external dose is small because of shielding by the uncontaminated soil cover. This BRA is dependent on the soil cover remaining intact at each of the waste sites.

For purposes of the FS, additional RESRAD analyses were completed assuming that no cover is intact. These analyses used the same input parameters as the analyses described above but do not include a cover (see Appendix E for more details). This was accomplished to identify whether an excess dose would be observed if the existing covers were to be removed (i.e., no ICs to maintain the current cover). The 216-B-63 Trench was the only waste site to have an estimated dose greater than the 15 mrem/y within a 150-year time frame. This outcome is discussed more in Chapter 7.0.

3.4.3 Human Health Risk Assessment Summary and Uncertainty Discussion

The uncertainties inherent to risk assessment can be numerous, lending to either overestimation of risk or underestimation of risk. Removing *all* uncertainty is an unobtainable goal in health risk assessment. Sufficient information and a clear understanding of the uncertainties are critical to support informed risk management decisions (EPA/540/G-89/004).

Minimal human-health risks for an industrial scenario were identified in this BRA. No COCs greater than acceptable risk criteria were identified. Detected constituents were eliminated either at the data-evaluation phase or in the risk-assessment phase. Further information on the conclusions of this analysis and its implications to the FS is discussed in Section 3.7.

In this assessment, the major uncertainties relate to the following:

- Development of representative media concentrations
- Exposure factors
- Toxicity information
- Characterization of risks.

The approach for this risk assessment was to adopt conservative procedures to avoid false-negative risk determinations. That is, health protective procedures were used to avoid underestimation of risk. Health risk evaluation procedures are inherently designed to err on the side of retaining COPCs for further evaluation in risk characterizations. Based on anticipation of uncertainty when quantifying exposure and toxicity, the health risks and hazards presented in this risk assessment are more likely to indicate that contaminants are greater than target risk goals, although health risks actually may be negligible. Risk-assessment methodology is less likely to indicate that contaminants are not a health risk when they actually are. This process is necessary to ensure the protection of human health. Because unacceptable risk and specific risk drivers were not identified based on this conservative approach, it can be assumed with more certainty that the risks to an industrial worker based on the available data would be negligible.

3.4.3.1 Uncertainties with the Concentration Data

The biased sampling approach employed at these waste sites is an underlying factor contributing to much of the uncertainty in this risk assessment. Because a biased sampling approach was used to collect samples from the worst case/maximum contaminant conditions, and the maximum results were used to represent the entire ditch, trench or pond, the exposure-point concentrations likely are overestimated and lead to false-positive risk results. However, large areas were not sampled, and some samples were not analyzed for the full suite of contaminants. These omissions were professional judgments exercised in the RI. As a result, there may be uncertainties regarding the representativeness of the samples in characterizing the exposure area. These uncertainties may cause hesitation in trusting that the biased results also bias the assessment toward an overestimate of risk, and it may be possible that worst case conditions were not identified by the sparse sampling locations. However, the backfill currently covering all waste sites except a portion of the 216-S-10 Ditch likely prevents exposure to employees working on top of the waste sites. This is especially true with the nonradionuclide assessment where a cover was not considered in the cleanup level calculation.

3.4.3.2 Uncertainties in the Exposure Factors

The exposure factors used in the evaluation process generally are selected to be protective of human health. Typically, if COPCs are not eliminated in the evaluation process, then site-specific exposure factors are applied in the exposure assessment, and these contaminants may be eliminated in the risk-characterization phase. For these waste sites, the selection of the industrial land-use scenario in the foreseeable future is the most significant determination relative to current and potential future exposures. This scenario, coupled with the assumption that clean cover at these sites will be maintained in the future, assumes that little direct contact can occur. The largest uncertainty in the human-health risk assessment relates to these assumptions and is the key issue for risk managers to consider.

With regard to the estimated exposures, the true level of human contact with contaminated media adds to the uncertainty. In general, when exposure data are limited or absent, the exposure parameters were selected in a conservative manner. The values selected are intended to more likely overestimate than underestimate actual exposure and risk. For human receptors, outdoor workers at DOE radionuclide sites typically will be required to be in personal protective wear, and the amount of soil ingestion and dust inhalation likely may not be as intense as the exposure assumptions used for an industrial scenario at non-DOE sites. In addition, by completing a risk assessment at each site, the assumption that site workers are at each of the waste sites for the entire exposure duration likely is conservative. For example, a site worker may be in the area of the 216-S-10 Ditch, but that may include the 216-S-10 Pond, 216-S-11 Pond, and neighboring waste sites. The exposure assumptions used likely overestimate actual risk. The most significant uncertainty for radionuclide exposure concerns the long-term applicability of the assumptions that workers will work indoors 75 percent of the time, that no excavation will penetrate the clean surface layer, and that the surface layer will remain intact.

3.4.3.3 Uncertainties in the Toxicity Information

Each site contaminant was compared to background concentrations and considered for their essential-nutrient status. The nonradionuclides then were compared to cleanup levels based on established toxicity criteria. Each of these evaluation procedures is conservative in nature and is more likely designed to obtain false-positive, rather than false-negative, identification COCs. Established toxicity criteria typically have uncertainty safety factors of 10 to 10,000 times. A number of COPCs did not have toxicological data and could not be evaluated quantitatively. These analytes are a source of uncertainty and may lead to an underestimation of overall risk.

Some of the qualitative COPCs identified were not selected as contaminants in the DQO document (BHI-01276) and were not required analytes in the Work Plan. Those included mesityl oxide, N-Butylbenzenesulfonamide, bismuth, and ammonia as NH_3. These were considered in this assessment because all available data were evaluated. Bismuth has human-health therapeutic uses in acceptable dosages. Other qualitative COPCs are common anions that typically are of concern only in high concentrations and that were evaluated in the context of the groundwater-protection pathway assessment.

The magnitude of the risk posed by these qualitative COPCs cannot be estimated. However, in some cases, the complete absence of a toxicity value sometimes is the result of a low level of concern regarding the chemical. These COPCs that lack toxicity factors likely contribute some added risk to exposed humans, but the level of added risk is unknown. Most importantly, however, the future land-use assumptions result in a low probability of humans contacting these contaminants.

Radionuclides greater than background concentrations were directly entered into RESRAD without further toxicity evaluation, because toxicity information is contained in the RESRAD code. Considerable uncertainty is associated with the radionuclide-dose conversion factors and slope factors applied in RESRAD for these calculations. These factors employ dose-response models that extrapolate from effects observed at relatively high radiation dose rates to the relatively low dose rates more common in environmental assessments. This type of dose-response model assumes that effects observed at high doses, such as cancer incidence, also could be observed at lower doses, albeit at correspondingly lower frequencies. As dose rates decrease, it is possible (though uncertain) that the model fails and that at some dose rates little or no correlation exists between dose and response.

3.4.3.4 Uncertainties in the Modeling and Risk Characterization

The baseline assessment of human-health risk is strongly dependent on the permanence of the uncontaminated cover. Without the uncontaminated cover at these waste sites, and with no action to remove contaminants, human-health risks may be observed in excess of 10^{-5} as shown in Table E-20 of Appendix E. The permanence of these covers for the protection of human health is dependant on DOE assuming control of this site in perpetuity and maintaining ICs. Because this is the plan for the foreseeable future, the assumption of uncontaminated covers at these waste sites is reasonable and reflective of baseline conditions.

3.5 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

A SLERA was performed for the 200-CS-1 OU sites. The SLERA is consistent with Steps 1 and 2 of the eight-step ecological risk-assessment process developed for the Superfund program as described in EPA/540/R-97/006 guidance. The primary purposes of Steps 1 and 2 are to quickly and efficiently identify analytes and sites with minimal potential for ecological risk and eliminate them from further evaluation. The first step, preliminary problem formulation, is considered a conservative, qualitative determination of whether ecological receptors, habitat, and exposure pathways are present at a site. The second step, ecological risk-based screening, is a conservative assessment of whether constituents detected at the 200-CS-1 OU are present at concentrations that are sufficiently high to indicate a potential for adverse health effects at the waste sites and to support a decision to proceed to a baseline ecological risk assessment (Steps 3 through 7 of the 8-step ecological risk-assessment process) or discuss remedial alternatives. Therefore, results of a SLERA are used to determine which of the following recommendations can be made:

- No further ecological investigations at the waste site

- Continuation of the risk-assessment process at the next level (baseline ecological risk assessment)
- Take a removal or remedial action to address potential risks.

For the 200-CS-1 OU sites, only the SLERA was performed (i.e., the first two steps of the EPA 8-step process) without the performance of the additional steps. As shown at the end of the SLERA, the ecological risks were deemed sufficiently characterized to recommend no further risk evaluation and to continue into an evaluation of remedial actions to mitigate the potential risks. Further details on the methodology of the ecological risk assessment, particularly the ecological risk-based screening, are presented below.

3.5.1 Screening-Level Ecological Risk-Assessment Methodology

The SLERA process used herein is described in DOE/RL-2001-54 and incorporates EPA methodology for Steps 1 and 2 of the ecological risk-assessment process. The following steps comprise the SLERA process:

1. Preliminary Problem Formulation – identify the chemical contamination, ecological habitat, receptors, and pathways of exposures
2. Ecological Risk Screen – Identify COPECs by comparing concentrations of chemicals in environmental media to various criteria
    a. Comparison of maximum detected soil concentrations from each representative waste site to the 90th percentile Hanford Site background concentration.
    b. Identify essential nutrients
    c. Comparison of maximum detected soil concentrations from each representative waste site to toxicity-based screening criteria.

These steps in the SLERA process are illustrated generically in Figure 3-5.

For nonradionuclides, the SLERA is consistent with the methodology in EPA/540/R-97/006; EPA/630/R-95/002F, *Ecological Risk Assessment Guidelines*; and the process outlined in WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures"). The methodology for the radionuclide ecological evaluation follows the process developed by DOE in DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic Terrestrial Biota*. In the second step of the SLERA, site media concentrations are compared to conservative risk-based media concentrations that are anticipated to be without ecological consequences. Contaminants with concentrations greater than screening criteria are identified as COPECs. Because the ecological risk assessment for the 200-CS-1 OU sites is limited to a screening-level assessment, a baseline ecological risk assessment has not been performed. The baseline ecological risk assessment typically refines the risk estimates for the COPECs and identifies which compounds should be designated as contaminants of ecological concern (COEC). For the SLERA, without a refinement of risk estimates, the assumption is generally made that COPECs are identified as contaminants of ecological concern. Chemicals that may be identified as COPECs based on concentrations greater that their screening criteria but that are not identified as COECs are discussed in Section 3.5.4 of this SLERA.

More detailed explanations of the risk-based screening methodology for nonradionuclides and radionuclides are presented in the following sections.

3.5.1.1 Nonradionuclides

Under WAC 173-340, a distinction is made between commercial and/or industrial and all other types of land use. For a commercial or industrial property, only potential exposure pathways to wildlife need to be considered (that is, plants and soil biota are not intended to be protected because of the site land use), while plants and soil biota must be considered along with wildlife at sites designated for other land uses. According to WAC 173-340-200, "Definitions," "industrial properties" are those that are or have been characterized by or are to be committed to traditional industrial uses such as processing or manufacturing of materials; marine terminal and transportation areas and facilities; fabrication, assembly, treatment, or distribution of manufactured products; or storage of bulk materials, that are zoned for industrial use by a city or county. Land use for the 200-CS-1 OU is designated industrial (exclusive). This designation will remain unchanged in the future because of land-use restrictions. Therefore, the SLERA is based on the assumption of exposures to ecological receptors under an industrial scenario.

3.5.1.2 Radionuclides

The WAC 173-340 regulations and the screening values presented in WAC 173-340-900, Table 749-3, address only nonradionuclide chemicals. Because radionuclides are present at the Hanford Site, biota concentration guide (BCG) screening values provided in DOE-STD-1153-2002 have been used to determine if radionuclides will be considered COEC. The default terrestrial wildlife BCGs are soil concentrations that have been calculated for a hypothetical small mammal and use high-end exposure assumptions that include, but are not limited to, the following: small body weight, high ingestion rate compared to body weight, continuous exposure to radiation from all directions, 100 percent area use, and an incidental soil-ingestion rate at 10 percent of the total diet. The model also assumes that a dose of 0.1 rad/d is protective of ecological populations. This dose is based on preventing effects to the most sensitive species tested. Each radionuclide-specific BCG represents the limiting radionuclide concentration in environmental media that would not be greater than DOE's recommended dose standards for biota. These BCG values represent conservative no-observed-adverse-effect-level (NOAEL)-based screening levels assumed to be protective of wildlife populations and include protection for potential radionuclide exposures through the food chain. In addition, because the effects of exposure to multiple radionuclides can be additive, all radionuclide fractions (maximum concentration/BCG) are summed as follows:

$$\text{Total risk estimate} = \sum (\text{maximum radionuclide concentration/BCG}).$$

If the total risk estimate (sum of all fractions) is less than 1.0, the potential for ecological risk is considered acceptable and the evaluation of radionuclides is complete.

The DOE guidance presents three levels to evaluate the potential risk to ecological receptors, with the first level being the most conservative (or most protective). Level 1 uses maximum detected concentrations, rather than the 95 percent upper confidence limit recommended by the WAC 173-340 regulations for the initial screening and is the level followed in this SLERA. Level 2 uses a comparison of the arithmetic mean concentrations against BCGs. Additional analysis using the RESRAD-BIOTA model (ANL, 2006, *RESRAD-BIOTA*) and more site-specific exposure assumptions then may be used to evaluate the ecological significance of any Level 2 exceedances. Level 3 comprises further modeling of doses and risks. As mentioned earlier, only the SLERA was performed (i.e., the first two steps of the EPA eight-step process). As shown at the end of the SLERA, the ecological risks were deemed sufficiently characterized to make a recommendation and to continue into an evaluation of remedial actions to mitigate the potential risks.

3.5.2 Preliminary Problem Formulation

The preliminary problem formulation step is a conservative, qualitative determination of whether ecological receptors, habitat, and exposure pathways are present at a site. It identifies the sources of contamination, the habitats and ecological receptors that may be present, and pathways for exposures of the receptors, and concludes with a conceptual site model for the ecological-exposure components of the site.

3.5.2.1 Ecological Setting

Information about the ecological setting at the 200-CS-1 OU is presented in more detail in DOE/RL-2001-54. The environmental setting encompasses the terrestrial habitats within the area of the waste sites. The availability and quality of terrestrial habitats determines the wildlife types that can be present and the likelihood that they use areas associated with the waste sites in the study area.

3.5.2.1.1 Terrestrial Habitats and Vegetation at the 200-CS-1 Operable Unit Waste Sites

Environmental monitoring has been an ongoing activity since the early days of the Hanford Site. The monitoring activities continue today, and a significant body of information exists about the ecology of the Central Plateau. The latest data-collection activities that focused on the Central Plateau were conducted in 2000 and 2001. The information collected was compiled in DOE/RL-2001-54.

The Hanford Site is located within the Columbia Basin eco-region, a 14.8 million acre region once dominated by steppe and shrub-steppe vegetation (*Natural Vegetation of Oregon and Washington* [Franklin and Dyrness, 1973]). Today, an estimated 60 percent of the shrub-steppe habitat in the State of Washington has been converted to other uses by humans, as reported in *Biodiversity Inventory and Analysis of the Hanford Site, Final Report 1994-1999* (TNC, 1999).

The habitats associated with the Central Plateau have been characterized, mapped, and described in recent years in WHC-SD-EN-TI-216, *Vegetation Communities Associated with* *the 100-Area and 200-Area Facilities on the Hanford Site*; TNC (1999); and documents produced by the Pacific Northwest National Laboratory (e.g., PNL-8942, *Habitat Types on the Hanford Site: Wildlife and Plant Species of Concern*; PNNL-13230, *Hanford Site Environmental Report 1999*).

ICs and limited access to the Hanford Site for nearly 60 years have preserved the shrub-steppe ecosystems in some areas, while other locations (e.g., facilities, waste sites) are highly disturbed. The Hanford Site as a whole and the U.S. Department of Defense Yakima Training Center are considered significant parcels within the Columbia Basin eco-region, because they contain the largest remaining areas of relatively undisturbed shrub-steppe habitat (*Evaluating the Conservation of Avian Diversity in Eastern Washington: A Geographic Analysis of Upland Breeding Birds* [Smith, 1994]; and TNC, 1999).

The shrub-steppe community present on the Hanford Site is characterized by three or four layers of vegetation, depending on its stage of succession. The area surrounding the 200-CS-1 OU representative waste sites contains two of the eight representative vegetation community types found on the Central Plateau. At the waste sites in the 200 East Area, the vegetation surrounding the waste sites consists of crested wheatgrass. Crested wheatgrass also is found in the immediate vicinity of the 216-B-63 Trench, but the surrounding area consists of the cheatgrass/Sandberg's bluegrass vegetation community. In the 200 West Area, the 216-S-10 Pond and Ditch lie in the cheatgrass/Sandberg's bluegrass vegetation community. All of the eight vegetation communities and the available census data on plant, bird, and mammal species are described in depth in DOE/RL-2001-54. A brief description of the vegetation and wildlife in the two communities found at the representative waste sites follows.

Crested Wheatgrass Community. Many of the waste sites within this community represent stabilized or revegetated sites and may be treated with herbicides to control broadleaf plants. This community lacks diverse vegetation but may provide a more favorable habitat for large predatory arthropods than other plant communities. Vertebrate species found in this community include reptiles such as gopher snakes (*Pituophis melanoleucus*), side-blotched lizards (*Uta stansburiana*), and rattlesnakes (*Crotalus viridis*). Small mammals found in this community type include the Great Basin Pocket Mouse (*Perognathus parvus*), deer mice (*Peromyscus maniculatus*), house mice (*Mus musculis*), bushy-tailed woodrats (*Neotoma cinerea*), gophers (*Thomomys talpoides*), ground squirrels, black-tailed jackrabbits (*Lepus californicus*), and mountain cottontails (*Sylvilagus nutalli)*. Birds associated with this community include the American Robin (*Turdus migratus*), the Western Meadowlark (*Sturnella neglecta*), Brewer's blackbird (*Euphagus cyanocephalus*), killdeer (*Charadrius viociferous*), long-billed curlew (*Numenius americanus*), chukar (*Alectoris chukar*), brown-headed cowbird (*Molothrus ater*), and barn swallow (*Hirundo rustica*), as well as ravens, crows, magpies, juncos, and house sparrows (*Passer domesticus*). Arthropods found in the crested wheatgrass community are harvester ants (*Pogonomyrmex salinarius*), ground beetles (*Amara quenseli Schnoenherr*), darkling beetles (*Coniontis setosa Casey, Eleodes hispilabris imitabilis*, and *Philolithus densicollus Horn*), and camel crickets (*Ceuthophilus vicinus*).

Cheatgrass/Sandberg's Bluegrass Community. This grassland community lacks bunchgrasses, consisting mostly of the cheatgrass with up to 20 percent Sandberg's bluegrass as well as species such as Russian thistle, mustard, and hoary aster. The insect species in this community are similar to those found in the shrub-steppe areas, but seed-feeding arthropods are more abundant. Vertebrate species found in this community include reptiles such as gopher snakes (*P. melanoleucus*), side-blotched lizards (*U. stansburiana*), and rattlesnakes (*C. viridis*). Small mammals found in this community type include the Great Basin Pocket Mouse (*P. parvus*), deer mice (*P. maniculatus*), bushy-tailed woodrats (*N. cinerea*), gophers (*T. talpoides*), ground squirrels, black-tailed jackrabbits (*L. californicus*), and mountain cottontails (*S. nutalli*). Birds associated with this community include the American robin (*T. migratus*), the western meadowlark (*S. neglecta*), Brewer's blackbird (*E. cyanocephalus*), killdeer (*C. viociferous*), long-billed curlew (*N. americanus*), chukar (*A. chukar*), brown-headed cowbird (*M. ater*), horned lark (*Eremophilia alpestris*) barn swallow (*H. rustica*), as well as California quail (*Callipepla californica*), ring-necked pheasants (*Phasianus colchicus*), mourning doves (*Zenaida macroura*), ravens, crows, magpies, juncos, and house sparrows (*P. domesticus*). Arthropods found in the cheatgrass/Sandberg's bluegrass community are ground beetles (*A. quenseli Schnoenherr, Dicheirus piceus Menetries,* and *Harpalus fraternus LaConte*), darkling beetles (*Blapstinus discolor Horn, C. setosa Casey, Eleodes novoverrcula Boddy,* and *P. densicollus Horn*), and camel crickets (*C. vicinus*).

Large mammals including badgers (*Taxidiea taxus*), coyotes (*Canis latrans),* as well as some mule deer (*Odocoileus hemionus*) and an occasional elk (*Cervus elaphus*) may be found across almost all the vegetation communities including those described in the previous paragraphs. These species are highly mobile and not associated with a given vegetation community, but are likely to be found in and potentially feed in the outer areas surrounding the representative waste sites.

3.5.2.1.2 Aquatic Habitats

The 200 CS-1 OU contains no aquatic areas or aquatic habitat. Although some standing water potentially could remain after precipitation events, the waste sites at the 200-CS-1 OU do not contain permanent bodies of surface water. Therefore, only pathways associated with exposure to contaminated soil are considered to be complete at these sites.

3.5.2.2 Sensitive Habitat

Rare habitats are those identified in DOE/RL-96-32 as important for plant, fish, and wildlife species that have a low availability. Within the Central Plateau, the only identified rare habitat areas (rated as Level IV in DOE/RL-96-32) are located near the basalt ridges of Gable Butte and Gable Mountain. These basalt outcrops have limited availability, are associated with rare plant communities, and are easily disturbed. No waste sites are in close vicinity to these rare habitats. Wildlife likely to occur in these habitats are birds (prairie falcon [*Falco mexicanus],* rock wren *[Salpinctes obsoletus],* poorwill *[Phalaenoptilus nutallii],* and chukar), small mammals (yellow-bellied marmots [*Marmota flaviventris]* and woodrats *[N. cinerea]*), and reptiles (horned lizards, rattlesnakes [*C. viridis]*, and gopher snakes [*P. melanoleucus]*). Sensitive habitats include wetlands (or riparian) habitat (DOE/RL-96-32). Wetlands do not occur within the vicinity of the sites.

3.5.2.3 Endangered, Threatened, and Sensitive Species

Two federally protected species have been observed at the Hanford Site, the Aleutian Canada goose (*Branta Canadensis leucoparia*) and the bald eagle (*Haliaeetus leucocephalus*). Both depend on the river corridor and rarely are seen in the Central Plateau. As migratory birds, these species are protected under the *Migratory Bird Treaty Act* (1918). The ferruginous hawk (*Buteo regalis*) and the sage grouse (*Centrocercus urophasianus*) are State threatened species that reside in the sagebrush/steppe habitat; a small population of ferruginous hawks nest in the 200 Areas.

Several additional State and Federal special-status species, such as burrowing owls (*Athene cunicularia*), loggerhead shrike (*Lanus ludovicianusi*), long-billed curlew (*N. americanus*) and the sage sparrow (*Amphispiza belli*), are found in and near the 200 Areas. Of these, only the long-billed curlew is expected to be associated with the vegetation communities at these representative waste sites, although burrowing owls may be attracted to disturbed sites.

No plants, invertebrates, amphibians, reptiles, or mammals on the Federal or State of Washington threatened and endangered species lists are known to inhabit the Central Plateau. Sensitive species include threatened and endangered species, which are protected by Federal and State laws. The State of Washington defines sensitive species as any wildlife species native to the State of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the State without cooperative management or removal of threats (WAC 232-12-297, "Endangered, Threatened, and Sensitive Wildlife Species Classification").

3.5.2.3.1 Rare Plants

Rare plant species are vascular plant species listed by the Washington Natural Heritage Program (WNHP 1998) as endangered, threatened, or sensitive in the State of Washington. The Nature Conservancy survey discovered 112 populations of 28 rare plant taxa on the Hanford Site (TNC 1999). Although rare plants were found dispersed throughout the Site, the highest densities occurred on the east end of Umtanum Ridge, the basalt-derived sands near Gable Mountain, the White Bluffs, Rattlesnake Mountain, and the Yakima Ridge. Rare plants and sensitive habitats of concern occur within the 200 East and 200 West Area fence lines, but not on the waste sites themselves. In the 200 Areas, Piper's daisies (*Erigeron piperianus*) have been found in areas near the two representative waste sites. In the 200 West Area, the Piper's daisies are much farther from the representative waste sites (DOE/RL-2001-54).

3.5.2.3.2 Mammals of Concern

The State of Washington has classified the pygmy rabbit (*Brachylagus idahoensis*) as a candidate endangered species. None have been observed to date in the Central Plateau. The pygmy rabbit depends on sagebrush, primarily big sagebrush (*Artemisia tridentata*), and usually is found in areas where big sagebrush grows in very dense stands.

3.5.2.3.3 New-to-Science Species

The Nature Conservancy conducted a biodiversity survey of plants, mammals, reptiles, amphibians, birds, and insects at the Hanford Site between 1994 and 1998 (TNC 1999). This survey found two species and one variety of plants, and 41 species and two subspecies of insects that had not been known to science. A listing of the new plant and insect species (*Hanford* [Looney, 2007]) may be viewed at http://www.wsu.edu:8080/~zack/hanford.html .

Insects were dispersed throughout the Hanford Site, with the new species found in shrub-steppe, areas around the basalt talus, springs, and upland areas. The size, diversity, and relatively undisturbed nature of the Hanford Site shrub-steppe habitat have provided for a large and diverse insect population, of which the new-to-science species are a part. One of the new-to-science species, a ground-dwelling beetle (*Aphodius* new species) may be present at waste sites planted with crested wheatgrass, but a transect trapping study in the 200 East and 200 West Areas did not trap any *Aphodius* species (DOE/RL 2001-54).

The U.S. Fish and Wildlife Service and State of Washington have not yet determined the protective status of these new-to-science species (i.e., whether they are considered threatened or endangered). The habitat-based management plan at the Hanford Site will offer protection to most of these species. Except for some of the insects, none of these new-to-science species are expected to be located near the 200-CS-1 OU waste sites. Habitat protection is key to preserving the insect diversity at the Hanford Site.

3.5.2.4 Receptors of Concern

Receptors of concern are those ecological species that may be exposed to contaminants at the 200-CS-1 OU site. Based on the above descriptions of habitat and ecological organisms on the Central Plateau, the following can be identified as receptors of concern for the SLERA. Because the waste sites associated with the 200-CS-1 OU are located within the industrial (exclusive) land-use area, they are evaluated under industrial land use. Based on the definitions for ecological screening criteria in Ecology guidance (WAC 173-340), specific ecological organism groupings are evaluated under the industrial land-use scenario. It is assumed that soil biota on the site, such as plants and soil organisms, would be subjected to industrial activities, and risks to soil biota from site contamination are not considered. Thus, only wildlife such as birds and mammals that may forage at the site are considered receptors of concern under the industrial scenario.

- Industrial Scenario:
  - Terrestrial Mammals – Several species of small mammals are present on the Central Plateau and may visit the site and forage on plants and invertebrates. Predatory small mammals have been identified by Ecology (WAC 173-340-900) and EPA as receptors of concern with the highest potential for exposures to chemicals in soils.
  - Birds – Several species of birds are present on the Central Plateau and may visit the site. Predatory birds, specifically those that consume soil organisms, have

been identified by Ecology (WAC 173-340-900) and EPA as receptors of concern with the highest potential for exposures to chemicals in soils.

3.5.2.5 Potential Ecological Exposure Pathways

The conceptual model and exposure pathways for ecological receptors are described in Section 3.2. The major exposure pathways expected at the representative waste sites in the 200-CS-1 OU are direct ingestion of contaminated soil and ingestion of food items that have taken up contaminants from the soil. These pathways are the same pathways that were used to develop the screening levels for soil. Although some standing water potentially could remain after precipitation events, these sites have no permanent bodies of water; therefore, only pathways associated with exposure to contaminated soil are considered to be complete at this site.

The exposure pathways considered when developing the screening levels include all complete exposure pathways except for inhalation and dermal exposure. Although these pathways contribute to the dose of chemicals received by animals, the contribution from these pathways is expected to be relatively small and not to contribute significantly to receptor exposure (*Ecological Soil Screening Levels for Antimony* [EPA, 2003]). Inhalation is an insignificant pathway for contaminated soil in areas where plants cover the contaminated ground surface or where much of the contamination is buried. Dermal exposure to wildlife is mitigated by the fur or feathers that cover the bodies of most vertebrates. In addition, the incidental consumption of soil during grooming is assumed to be included in the direct soil-ingestion estimates. Dermal contact and inhalation/respiration pathways typically have not been assessed quantitatively in ecological risk assessments, based on guidance that suggests that the ingestion route is most important to terrestrial animals (EPA/540/R-97/006). Therefore, the exposure pathways considered when developing the screening values used for this site are likely to capture the primary exposure pathways for wildlife receptors at this site.

As described in Section 3.2.3, the point of compliance for evaluation of ecological receptors is from the ground surface to 4.6 m (15 ft) bgs. This depth is intended to represent a reasonable estimate of the depth of soil that could be excavated or disturbed at the soil surface resulting in the potential for ecological receptors to contact soil contaminants. The application of screening criteria to soil data within the top 15 feet assumes that the exposure of ecological receptors could occur to chemical concentrations anywhere within those top 15 feet. Burrowing depths of site-specific species were not taken into account because screening criteria were used to evaluate generic receptor species. The 4.6 m (15 ft) depth is deeper than the expected burrowing or rooting depth of species known to occur at the Hanford Site (DOE/RL-2001-54).

3.5.3 Selection of Ecological Risk-Based Screening Criteria

Ecological risk-based screening comprises the second step of the SLERA methodology. The ecological risk-based screening step characterizes the exposures of receptors of concern to site contamination, identifies toxicity-based criteria for the screening process, presents results of the screening steps, and identifies COPECs based on the screen. As described earlier, results of this step are intended for use in making future ecological risk-management decisions about the site. The risk-based screening process comprises descriptions of the assumed exposures of the receptors of concern and of the toxicity-based screening criteria, followed by presentation of the results of the screen.

3.5.3.1 Exposure Evaluation

As indicated earlier, receptors of concern are exposed to site contaminants at the 200-CS-1 OU through the ingestion of food and soil. In the SLERA, exposures to contaminants are not specifically quantified, but instead are evaluated through the comparison of maximum detected concentrations with the screening criteria that are specific to each receptor of concern. The amount of exposure of each receptor of concern to site contaminants is estimated by the use of exposure parameters that represent generic receptor species. These parameters are described below. The screening criteria consist of WAC 173-340-900 values, EPA ecological soil-screening levels, DOE BCGs, Oak Ridge National Laboratory toxicological benchmarks, and the scientific literature at large.

3.5.3.1.1 Exposure Parameters

The WAC 173-340-900 wildlife screening values assume an area use factor of 1.0 for the mammalian herbivore receptor (a vole), but use an area use factor of 0.52 for the avian predator (a robin) and an area use factor of 0.50 for the mammalian predator (a shrew) to represent that these receptors may use areas outside of the site under consideration. Remaining screening values used in this analysis assume that the receptor is exposed to the site 100 percent of the time. This assumption is the basis of the screening values developed for the DOE BCGs and the EPA ecological soil-screening levels.

All screening levels used in this SLERA incorporate 100 percent bioavailability of chemicals and radionuclides in soil and food items. For many chemicals, this assumption will overestimate the dose and therefore the potential risk to the ecological receptor. Although this assumption is conservative, it is the only appropriate assumption in the absence of site-specific information regarding the actual bioavailability of these chemicals.

Populations of receptors potentially at the site are considered in the screening phase to include all life stages of a species. Therefore, toxicity data available for growth, reproduction, or survival of any stage of the receptor's life cycle are used in developing the screening levels.

The exposure parameters that were used by the agencies in developing the screening values are designed to provide an appropriate level of conservatism for a screening assessment. The equations for soil concentration include the estimated intake through the food chain and through direct ingestion of soil by the receptor. Food ingestion rates usually are based on empirically derived allometric equations originally developed by Nagy (1987) (*Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds*). These allometric equations correlate food ingestion rate to body weight (EPA/600/R-93/187, *Wildlife Exposure Factors Handbook*). Body weights for receptor species used to develop screening levels are developed from EPA/600/R-93/187 or other literature values. Soil-ingestion rates generally are estimated as a percent of the total food intake (EPA/600/R-93/187).

Bioaccumulation factors (BAF) are used to estimate the concentration of contaminants within food items consumed by the receptor species on which the screening levels are based. The WAC 173-340-900 soil-screening values use K_{plant} to represent the plant uptake coefficient and BAF_{worm} to represent the earthworm BAF. Use of these factors accounts for the potential for some contaminants to concentrate at higher levels in food organisms such as invertebrates and plants than in the surrounding soil. These BAFs are conservative estimates of the reasonable maximum values and generally are based on the chemical properties of the contaminant, although empirical values sometimes are available.

3.5.3.1.2 Exposure-Point Concentrations

Exposure-point concentrations for this SLERA consist of the maximum detected concentration of contaminants within the top 4.6 m (15 ft) of soil (i.e., the range of 0 to 4.6 m bgs). Chemicals that never were detected at a waste site are not screened. Exposure-point concentrations of the chemicals detected at each waste site (i.e., maximum detected concentrations) are shown in the resultant screening tables in Section 3.5.3.4. Summaries of the soil data, including maximum concentrations, are presented in Appendix C for shallow-zone (0 to 4.6 m [15 ft]) nonradioactive chemicals and radionuclides.

3.5.3.2 Identification of Toxicity-Based Screening Criteria

The toxicity-based screening criteria are concentrations in environmental media that are expected not to result in population-level effects on species over their lifetime of exposure, including during sensitive reproductive and developmental stages of the organisms. For soils, the screening values are expressed in milligrams or micrograms per kilogram of soil. Because the soil-screening levels are applicable to the direct ingestion of food and soil by the ecological receptors, they have been developed from toxicity values that also are based on ingestion.

3.5.3.2.1 Nonradionuclides

For nonradionuclides, multiple sources of toxicity-based screening criteria were used in a hierarchical approach. The primary source comes from Ecology, as described below. Where screening levels are not available from Ecology, the remaining sources are used sequentially.

In the development of the available screening values, exposures were modeled for plants, soil invertebrates, mammals, and birds. Other categories of receptors, such as reptiles, were not included because adequate toxicity information was not available to develop safe doses of chemicals or radiation for these categories of organisms. The screening values for mammals and birds included animals modeled with different diets (herbivores and carnivores) but do not include receptors representing the higher level carnivores. Because the modeled herbivores and first-level carnivores (i.e., the shrew) generally have higher rates of exposure, because of their higher site fidelity and higher intake of food and soil on a body-weight basis, the screening levels used are intended to be protective of higher level carnivores as well.

To account for differences in doses and accumulation of chemicals by mammals, soil-screening values for wildlife were developed for species representing omnivores, carnivores, and herbivores. Where multiple mammalian wildlife values are available (e.g., as calculated under WAC 173-340-900, Table 749-4), the lowest of the soil-screening levels was selected as the screening value protective of wildlife.

Sources for the toxicity-based screening values consist of the following, listed in order of preference.

1. WAC 173-340-900, Table 749-3, "Ecological Indicator Soil Concentrations for Protection of Plants and Animals." These values represent conservative NOAEL-based screening levels that are protective of wildlife populations and include protection for potential chemical exposure through the food chain.

2. EPA Ecological soil-screening levels. The ecological soil-screening levels (*Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)*, Attachment 4-1, *Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs*, OSWER Directive 9285.7-55) developed by EPA (2007) for screening soils at contaminated sites were used for comparison to concentrations of nonradionuclides for which State of Washington values were not available.

3. ORNL – Oak Ridge National Laboratory, for the U.S. Department of Energy, has developed toxicity benchmarks for screening effects to biota from chemical contaminants in soil. ES/ER/TM-126/R2, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision*, provides toxicity benchmarks for soil and litter dwelling invertebrates, microbes, and microbial processes; ES/ER/TM-85/R3, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Terrestrial Plants: 1997 Revision*, provides toxicity benchmarks for plants; and ES/ER/TM-86/R3, *Toxicological Benchmarks for Wildlife: 1996 Revision*, provides toxicity benchmarks for wildlife.

4. Literature sources – For chemicals that lack screening values for wildlife from the above sources, screening benchmarks were developed from guidance provided by Ecology in WAC 173-340. A detailed description of the derivation of surrogate screening benchmarks is provided in the following section.

As mentioned above, the screening values presented in WAC 173-340-900, Table 749-3, were given highest priority, followed by the ecological soil-screening levels and the ORNL values. For all sources, the screening values generally are based on doses that are expected to be low enough not to impact the health of the species.

3.5.3.2.2 Development of Screening Values from Literature Sources

For chemicals with no readily available screening values found in Sources 1 through 3 above, surrogate screening benchmarks were developed, as mentioned in Source 4 above. The development of surrogate screening benchmarks is based on guidance provided in

WAC 173-340-7493(4), "Site-Specific Terrestrial Ecological Evaluation Procedures," "Literature Surveys," which presents the recommended procedure for deriving the screening values, termed Soil Indicator Concentrations. The soil-indicator concentrations account for exposures through ingestion of food as prey items exposed to soil, and for the incidental ingestion of soil. Chemical concentrations for food items are developed through bioaccumulation factors to relate soil concentrations to soil-biota concentrations (i.e., earthworms as surrogates for soil biota), and plant uptake coefficients to relate soil concentrations to plant-tissue concentrations. The soil-indicator concentrations then are determined as the ratio of the toxicity reference value to the dose of chemical that the wildlife receptor will receive, as calculated from the ingestion of soil and contaminated food items.

Wildlife receptors used to derive soil-indicator concentrations, as provided in WAC 173-340-900, Table 749-4, consist of the short-tailed shrew to represent mammalian predators, the American robin to represent avian predators, and the meadow vole to represent mammalian herbivores. Once soil-indicator concentrations were calculated for each of these three representative receptors for each chemical, the lowest of the three concentrations was selected as the screening value for that chemical.

The equations in WAC 173-340-900, Table 749-4, for calculating soil-indicator concentrations are as follows.

Mammalian predator:

$$SC_{MP} = (T_{Shrew})/[FIR_{Shrew,DW} \text{ x } P_{SB\ (shrew)} \text{ x } BAF_{Worm}) + (SIR_{Shrew,DW} \text{ x } RGAF_{Soil,shrew})]$$

Avian predator:

$$SC_{AP} = (T_{Robin})/[FIR_{Robin,DW} \text{ x } P_{SB\ (Robin)} \text{ x } BAF_{Worm}) + (SIR_{Robin,DW} \text{ x } RGAF_{Soil,robin})]$$

Mammalian herbivore:

$$SC_{MH} = (T_{Vole})/[FIR_{Vole,DW} \text{ x } P_{Plant,\ vole} \text{ x } K_{Plant}) + (SIR_{Vole,DW} \text{ x } RGAF_{Soil,vole})]$$

where,

SC_{MP}, SC_{AP}, SC_{MH}	=	Soil concentration (mammalian predator, avian predator, mammalian herbivore)
T_{Shrew}, T_{Robin}, T_{Vole}	=	Toxicity reference value (shrew, robin, vole) – mg/kg-day
FIR	=	Food ingestion rate, default values (shrew, robin, vole) – kg dry food / kg body weight-day
P	=	Proportion of contaminated food in the diet, default values (soil biota for shrew and robin, plant for vole)
K_{Plant}	=	Plant uptake coefficient, chemical-specific default values (vole) – mg/kg plant / mg/kg soil

BAF_{Worm}	=	Earthworm (surrogate soil biota) bioaccumulation factor, chemical-specific default values – mg/kg worm / mg/kg soil
SIR	=	Soil ingestion rate, default values (shrew, robin, vole) – kg dry soil / kg body weight-day
RGAF	=	Gut absorption factor for a chemical in soil relative to the factor for a chemical in food, chemical-specific default values (shrew, robin, vole).

In the first step of the procedure, toxicity data were identified for exposures of wildlife receptors to the chemicals of interest. The values were taken as the lowest available lowest-observed-adverse-effect level (LOAEL) from Table 12 in ES/ER/TM-86/R3. For those chemicals with no LOAEL in the ORNL document, the NOAEL was used. When a toxicity value was not available for a chemical in the ORNL document, the COPEC selection indicates that screening criteria are absent; no secondary sources for toxicity data were used.

The second step was to compile K_{plant} and BAF_{worm} values for each chemical using the footnotes to WAC 173-340-900, Table 749-5. For the K_{plant} values, the default value of 1.01 was used from Table 749-5 for metals and metalloid elements. For organics, the values were calculated as K_{plant} = 10^(1.588-(0.578 Log K_{ow}). The BAF_{worm} values for each chemical were taken as the default values in Table 749-5.

Finally, these parameters were input into the equations presented above to calculate the soil-indicator concentrations. Parameter values (i.e., Log K_{ow}, K_{plant}, and BAF_{worm}), toxicity data, data sources, and equations used in the derivation of the soil-screening criteria are provided with the resultant surrogate soil-indicator concentrations in Table 3-6. Surrogate soil-indicator concentrations were developed for chemicals that were detected in soils from at least one of the sites and were missing screening criteria from the readily available sources. Data were available to develop soil-indicator concentrations for the following chemicals:

- 1,2-Dichloroethane
- Acetone
- Aluminum
- Aroclor-1254
- Benzene
- Bis(2-ethylhexyl)phthalate
- Boron
- Cyanide
- Dibutyl diethyl phthalate
- Diethyl phthalate
- Fluoride
- Methylene chloride
- Nitrate
- Tetrachloroethylene
- Thallium
- Tin
- Toluene

- Uranium
- Xylenes (total).

The lowest soil-indicator concentration calculated for each of these chemicals was selected as the wildlife screening value for that chemical.

3.5.3.2.3 Sources of Screening Criteria for Radionuclides

The radionuclide screening levels used for screening wildlife at the 200-CS-1 OU are the BCGs developed for the Hanford Site in DOE-STD-1153-2002. That document was prepared for DOE by the Biota Dose Assessment Committee and presents BCGs for radionuclides, along with a methodology for conducting ecological risk assessments for radionuclides. DOE/RL-2001-54 contains additional details on the Biota Dose Assessment Committee document.

The BCGs are based on a total dose of 0.1 rad/d to the terrestrial wildlife species and include both the internal dose from ingestion of radionuclides in food or soil and the external dose from surface exposure to soil. The radiation dose of 0.1 rad/d was established as a predicted safe chronic exposure dose by the International Atomic Energy Agency in 1992 (IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*) and the United Nations Scientific Committee on the Effects of Atomic Radiation (*Sources and Effects of Ionizing Radiation Report to the General Assembly and Scientific Annex* [UNSCEAR 1996]).

The BCGs for terrestrial systems consider both terrestrial plants (1.0 rad/d dose) and terrestrial animals (0.1 rad/d dose) and are developed to be protective of populations of these terrestrial plant and animal species. The radionuclide BCGs are expressed in units of picocuries per gram of soil.

3.5.3.3 Background Comparison and Essential-Nutrient Evaluation for SLERA

As described in Section 3.3, the selection of COPC/COPEC process consisted of the comparison of maximum detected concentrations from each waste site to 90th percentile Hanford Site background value and evaluation of essential-nutrient status before making comparisons based on toxicity. The background and essential-nutrient evaluations are performed only for inorganics and radionuclides. A summary of the results of the background comparisons for inorganic chemicals is presented in Tables 3-7a through 3-7d. These chemicals are carried through to the toxicity-based screening.

At the 216-S-10 Ditch and 216-B-63 Trench sites, vanadium was not retained as a COPEC. Although vanadium and these sites were greater than the 90th percentile background value, the maximum detected concentrations of vanadium at these sites were also compared to 90 percent upper confidence limit and the 95th percentile measures of Hanford Site background vanadium. At both sites, vanadium concentrations were considered to be within the upper range of naturally occurring concentrations (see Table 3-1). At the 216-A-29 Ditch, the maximum concentration of vanadium was above the evaluated measures of background and was retained for the SLERA at that site.

The maximum concentration of ammonia at the 216-B-63 Trench was above the 90th percentile Hanford Site background value. Ammonia at this waste site was also compared to the 95th percentile concentration for the Hanford site. Based on this comparison, ammonia also was not retained as a COPEC as it is within the upper range of naturally occurring ammonia concentrations (see Table 3-1).

Essential nutrients for wildlife evaluated in the SLERA are considered to be the same as those identified in the human-health risk assessment. Maximum detected values of the essential nutrients calcium, potassium, and sodium were above background levels only at the 216-A-29 Ditch. As shown in Tables 3-7a through 3-7d, the maximum values for these analytes ranged from approximately 5 percent (potassium) to 29 percent (calcium) greater than the lognormal 90th percentile background levels. Because the 95th percentile and the 90 percent upper confidence limit show that these values are either within background range (potassium) or approximately 16 percent (calcium) greater than background, the maximum concentrations of these analytes are considered to meet the criterion of being only slightly higher than background (EPA/540/1-89/002). Therefore, these essential nutrients are not further evaluated in the SLERA.

Inorganic compounds such as ammonia, chloride, nitrite, phosphate, sulfate, and sulfide do not have readily available screening criteria or toxicity data, and are also considered essential nutrients, particularly to plant. In some cases, the maximum detected concentrations for these constituents were greater than their respective background values. However they were not carried forward into the next step of the evaluation due to the lack of toxicity criteria and their status as nutrients. For other chemicals, including some essential nutrients, for which ecological screening criteria were not available, toxicity data were retrieved and used to develop surrogate criteria as described previously. These chemicals include cyanide, fluoride, and nitrate.

Those contaminants with maximum concentrations less than their 90th percentile Hanford Site Background value were not carried forward into the next step of the evaluation and are not considered COPECs.

3.5.3.4 Results of Toxicity-Based Evaluation

A comparison of maximum detected soil concentrations from each waste site were made to the toxicity-based criteria described in the previous section.

3.5.3.4.1 Nonradionuclides

Tables 3-7a through 3-7d present the screening results for nonradionuclide chemicals at each waste site based on an industrial land use designation. Shaded rows in each table designate contaminants with maximum detected concentrations that are greater than the 90th percentile Hanford Site background and are also greater than their respective screening level and are subsequently identified as COPECs. Chemicals whose maximum detected concentrations were within their respective background concentrations were not considered COECs (and are not shaded). Those contaminants that are reported with a maximum detected concentration greater than the screening criteria are considered COECs without further refinement or evaluation of their ecological risks and are referred to as such hereinafter.Results of the screening process and identification of COECs at each site, based on comparison to wildlife screening values for industrial land use, are summarized in the following paragraphs.

216-A-29 Ditch. Chemicals identified as COECs because their maximum detected concentrations were greater than applicable screening values (see Table 3-7a):

- Arsenic
- Cadmium
- Lead
- Selenium
- Silver
- Thallium
- Vanadium
- Aroclor-1254
- Bis(2-ethylhexyl)phthalate
- Dibutyl phthalate.

Chemicals retained for further consideration because they were greater than background values but did not have screening levels available for comparison:

- Ammonia
- Sulfate.

The maximum concentration of chloride was measured at more than twice the background level at this site; however, chloride has no screening criterion and may be considered an essential nutrient.

Chemicals retained for further consideration because of the lack of background and screening levels:

- PAHs [benzo(a)anthracene, benzo(b)fluoranthene, chrysene, fluoranthene, phenanthrene, pyrene]
- Bismuth
- Butyl benzyl phthalate
- N-Butylbenzenesulfonamide
- Mesityl oxide
- Motor oil TPH
- Tributyl phosphate.

216-B-63 Trench. Chemicals identified as COECs because their maximum detected concentrations were greater than applicable screening values (see Table 3-7b):

- Antimony

- Selenium
- Thallium
- Aroclor-1260.

Although the maximum concentration of vanadium was greater than its screening criterion, it was not greater than the range of background concentrations and was not identified as a COECs.

Chemicals retained for further consideration because of exceedance of background, but no screening level was available for comparison:

- Phosphate.

Chemicals retained for further consideration because of the lack of background and screening levels:

- Bismuth
- Nitrite
- Sulfide
- 2-Ethylhexanol
- Di-n-octyl phthalate.

216-S-10 Ditch. Chemicals identified as COECs because their maximum detected concentrations were greater than applicable screening values (see Table 3-7c):

- Total chromium
- Copper
- Selenium
- Silver
- Thallium
- Zinc
- Aroclor-1254
- Dibutyl phthalate.

Chemicals retained for further consideration because of the lack of background and screening levels:

- PAHs [acenaphthene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3)pyrene, phenanthrene, pyrene]
- Bismuth
- Butyl benzyl phthalate
- Carbazole
- Nitrite.

216-S-10 Pond. Chemicals identified as COECs because their maximum detected concentrations were greater than applicable screening values (see Table 3-7d):

- Selenium
- Silver
- Thallium.

Chemicals retained for further consideration because of the lack of background and screening levels:

- Nitrite
- Sulfide.

3.5.3.4.2 Radionuclides

The maximum concentration of each radionuclide was compared to its BCG. The results for both detected and nondetected compounds were evaluated. Each radionuclide was screened against its individual dose guideline (i.e., BCG); therefore, no comparisons were made to gross-alpha and gross-beta measurements.

Table 3-8 presents the screening results for radionuclide COECs at all four sites using the BCG. All radionuclides are included, and results indicate whether the radionuclide was detected and whether the detected concentration was greater than background. A comparison of soil concentration with the BCG was made for any radionuclide for which a BCG was available, regardless of whether the radionuclide concentration was at or below the background concentration. Rows in the tables that are shaded designate COECs with maximum concentrations greater than background and industrial screening levels, or for which no background or screening levels were available. Radionuclides whose maximum detected concentrations were less than background concentrations were not retained (and are not shaded in Table 3-8).

216-A-29 Ditch. Radionuclides identified as COECs because their maximum detected concentrations were greater than background and applicable screening values:

- Cesium-137.

Radionuclides retained for further consideration because they were greater than background but did not have screening levels available for comparison:

- Plutonium-238 (the maximum concentrations were greater than background by 4,000-fold)

- Thorium-230.

Radionuclides retained for further consideration because of the lack of background and screening levels:

- Bismuth-212
- Bismuth-214
- Lead-212
- Lead-214
- Neptunium-237
- Thallium-228.

216-B-63 Trench. Radionuclides identified as COECs because their maximum detected concentrations were greater than background and applicable screening values:

- Cesium-137
- Strontium-90.

Radionuclides retained for further consideration because they were greater than background but did not have screening levels available for comparison:

- Thorium-230.

Radionuclides retained for further consideration because of the lack of background and screening levels:

- Neptunium-237
- Radium-224.

216-S-10 Ditch. Radionuclides identified as COECs because their maximum detected concentrations were greater than background and applicable screening values: None.

Radionuclides retained for further consideration because they were greater than background but did not have screening levels available for comparison:

- Thorium-230.

216-S-10 Pond. Radionuclides identified as COECs because their maximum detected concentrations were greater than background and applicable screening value: None.

Radionuclides retained for further consideration because they were greater than background but did not have screening levels available for comparison:

- Thorium-230.

Radionuclides retained for further consideration because of the lack of background and screening levels:

- Carbon-14.

3.5.3.5 Summary of Ecological Screening and Contaminants of Ecological Concern Selection

Table 3-9 summarizes the exceedance factors for all chemicals and radionuclides for which industrial soil ecological-screening criteria were available. Exceedance factor is defined as the ratio of the maximum detected concentration divided by the screening level. Chemicals for which the maximum concentrations were greater than both the background values and the ecological screening criteria are identified as COECs. As per the approach to the ecological risk assessment for the 200-CS-1 OU, those chemicals identified as COPECs are subsequently accepted as COECs without further refinement or evaluation of their ecological risks. Those compounds that were greater than background but were not greater than the screening criteria are not identified as COECs. Those chemicals missing screening criteria or background values are considered qualitatively and are identified for further potential evaluation.

For a few chemicals, the background concentration was found to be greater than the ecological screening criterion:

- Aluminum: Background concentration = 11,800 mg/kg; screening criterion = 107 mg/kg
- Barium: Background concentration = 132 mg/kg; screening criterion = 102 mg/kg
- Vanadium: Background concentration = 85.1 mg/kg; screening criterion = 7.8 mg/kg.

Of these chemicals, only vanadium was found to be greater than its screening level at two sites, yet the maximum concentration fell within background. At a third site (the 216-A-29-Ditch), the maximum vanadium concentration at 104 mg/kg was slightly over the background level of 85.1 mg/kg.

In summary, a total of 11 metals, 4 organic chemicals, and 2 radionuclides were identified as COECs in soil at the 200-CS-1 OU, based on exceedance of soil-screening criteria. Each site contained contaminants that were identified as COECs, based on criteria exceedances: 11 contaminants at the 216-A-29 Ditch including 1 radionuclide; 6 contaminants at the 216-B-63 Trench including 2 radionuclides; 8 contaminants at the 216-S-10 Ditch; and 3 contaminants at the 216-S-10 Pond.

Some chemicals were identified as COECs at more than one site. Thallium and selenium were identified as COECs at all four sites; silver and polychlorinated biphenyls were identified as COECs at three sites; and dibutyl phthalate was identified as a COEC at two of the sites. Of the radionuclides, Cs-137 was identified as a COEC at the 216-A-29 Ditch and 216-B-63 Trench sites, and Sr-90 was identified as a COEC at the 216-B-63 Trench site.

In addition, at each site, numerous detected chemicals were identified that were greater than background but had no ecological screening criteria, or for which no background or screening criteria were available. These chemicals are identified in the final list of COCs for the four sites. At the 216-A-29 Ditch, 22 contaminants were identified as lacking screening criteria or lacking screening criteria and background values. At the 216-B-63 Trench, nine contaminants were identified as lacking screening criteria or screening criteria and background values. At the 216-S-10-Ditch, 18 detected contaminants were identified as lacking screening criteria or screening criteria and background values. At the 216-S-10 Pond, four chemicals were identified as lacking screening criteria or screening criteria and background values.

Appendix A presents tables of all of the analytical data, including nondetected organic chemicals and the detected concentrations of the chemicals excluded as essential nutrients.

3.5.4 Summary and Uncertainty Assessment

The SLERA performed for the 200-CS-1 OU sites identified 17 chemicals as COECs in the shallow-zone soil (i.e., top 4.6 m [15 ft]), based on exceedance of ecological screening criteria. Numerous other chemicals were identified as lacking screening criteria or lacking data on background concentrations. Because of the industrial nature of the site, the screening criteria were selected for the protection of wildlife receptors, which consist of mammalian and avian predators who may consume contaminated prey and soil from the sites. The SLERA was determined not to need further refinement in a baseline ecological risk assessment, so these COECs further are identified as COCs for the purpose of managing ecological risks at the sites and for estimating remediation options for site soils. The COCs based on ecological risks for the four waste sites in the 200-CS-1 OU are provided in Tables 3-7a through 3-7d and Table 3-8. Uncertainties in the SLERA and the resultant identification of COECs are discussed below.

3.5.4.1 Screening-Level Ecological Risk Assessment Process

The SLERA process is designed to be a conservative screen of potential ecological risks at the sites. Further refinement of ecological risks typically is performed in a baseline ecological risk assessment, which was not conducted for the 200-CS-1 OU sites. Instead, the conservative assumption was made that the COPECs identified through the screening process will serve as COECs for the sites. Typically, a baseline ecological risk assessment, through the refinement of the risk process, may identify fewer COECs than are identified as COPECs. Remediation of site soils based on COECs identified through the SLERA is considered a conservative approach to managing the potential ecological risks posed by contaminated soils at the sites.

The soil-screening levels used in the SLERA were designed to provide concentrations that were protective enough to be used to eliminate potential contaminants at a wide range of sites. For the industrial scenario assumed for the 200-CS-1 OU in this SLERA, the screening levels are based on potential risk to birds and mammals as wildlife that may use the site soils for foraging. The screening levels are based on generic receptor species within these feeding guilds; the receptors are not designed to be specific to this site, nor are the exposure parameters that were chosen for each receptor. For example, screening criteria were not available for arthropods or reptiles that may be more abundant at the site than the representative receptors of concern identified for the SLERA. The only species-specific exposure parameters used to generate the screening levels are body weight (from which the food ingestion rate is calculated using allometric scaling) and the soil-ingestion rate for shrews, robins, and voles. The soil-ingestion rate is estimated as a percentage of the total food-ingestion rate. The estimated soil concentration corresponding to ingestion of a chronic reference dose will depend primarily on these ingestion parameters. The receptors of concern identified for the site included mammals and predatory birds, which are represented by the surrogate species and feeding guilds that the screening criteria are designed to protect. The wildlife receptors that the screening criteria are developed for consist of shrews as mammalian predators, robins as avian predators, and voles as mammalian herbivores. Because of the nature of the exposures of these receptors, they are considered suitable surrogates to represent all potential receptors at the site, including larger mammals and reptiles.

3.5.4.2 Area Use by Wildlife Receptors

Some of the screening levels used in this SLERA are based on an assumption that the area use factor for all wildlife receptors was 1.0. For example, this assumption is the basis of all of the screening values developed for the DOE BCGs and the EPA ecological soil-screening levels. The WAC 173-340-900 screening levels for the mammalian herbivore assume an area use factor of 1.0, but the area use factor for the other wildlife receptors was assumed at approximately 0.5 for developing the screening levels (WAC 173-340-900, Table 749-4). In other words, the wildlife receptors were assumed to use the site approximately 50 percent of the time as foraging area, using the WAC 173-340-900 screening levels. The assumptions of area use may result in screening levels that over- or underestimate the potential risk to the ecological receptors, depending on actual foraging use of the site. A more refined evaluation of the potential exposures to wildlife receptors would necessitate a comparison of the area use by species present within the sites with the home ranges used in developing the screening levels. The potential exposure of a single receptor to multiple sites also would need to be considered.

3.5.4.3 Exposure Estimates

Exposures of wildlife to soil contaminants were assumed to occur to chemicals at the highest concentration within 4.6 m (15 ft) of the soil surface. Typically, wildlife receptors will be exposed to near-surface soils during foraging, although burrowing animals, such as owls, and wildlife that consume plants with deep roots could be exposed to contaminants down to 4.6 m (15 ft) bgs. Under refinement of risks in a baseline ecological risk assessment, a reasonable maximum exposure scenario typically would assume that wildlife receptors are exposed to an upper bound average concentration throughout the top 1.8 m (6 ft) of soil (EPA/540/R-97/006). Actual exposures over the lifetime of a receptor would be less. The use of the maximum concentrations in the top 4.6 m (15 ft) is a conservative approach in the SLERA that is designed to avoid underestimating exposures.

The screening criteria are based on the assumption that exposures to soil contaminants occur through the consumption of food items and soil from the sites. Inhalation of volatiles and dust particles from soil was not considered, which could underestimate potential exposures. Differences in dietary composition between receptors of concern at the site and the surrogate receptors that the screening criteria are based on can affect the calculation of a soil-indicator concentration for a contaminant. Herbivores consume a larger mass of food to meet their caloric needs, but contaminants may accumulate to higher levels in the prey consumed by omnivores and carnivores. To account for differences in accumulation and consumption, the screening levels calculated soil levels for species representing omnivores, carnivores, and herbivores. The lowest of these soil levels then was considered to be protective of wildlife. This assumption provides appropriate protection for all wildlife species regardless of the composition of their diet.

The concentrations of contaminants in the food items that are assumed to be consumed by receptors of concern are estimated by use of uptake factors. For earthworms, which represent soil-biota food items for mammalian and avian predators, tissue concentrations are based on BAFs, which are provided in WAC 173-340-900, Table 749-5. BAFs are used to estimate the concentrations of contaminants within the soil biota that are consumed by the receptor species for which screening levels are calculated. Use of these factors accounts for the potential for some contaminants to concentrate in higher levels in food organisms such as invertebrates and plants than in the surrounding soil. The BAFs are estimates generally based on the chemical properties of the contaminant, although empirical values sometimes are available. BAFs estimated from chemical properties may not adequately account for physiological regulation of chemicals within the organism or for excretion of chemicals from an organism. As a conservative measure for the SLERA, the BAFs generally overestimate the concentration of a contaminant within an organism that serves as food for another organism.

Site-specific bioaccumulation data would be helpful in understanding whether the risks predicted by the screening-level exceedances are reflected in elevated tissue concentrations in small mammals at the waste sites. This could be accomplished by measuring COPECs in trapped surrogate mammalian and avian predators and in food items and soil samples collected at the foraging areas of the sites.

3.5.4.4 Toxicity Reference Values

The suite of available screening levels in the five identified sources was limited; over half of the COPECs retained for further consideration were retained because no screening value was available in the selected set of values. Because of the lack of readily available screening criteria, surrogate soil-indicator concentrations were calculated based on toxicity reference values taken from the literature for a number of detected chemicals. However, the identification of toxicity reference values was limited to those readily available in compiled sources, which consisted of the ORNL document on developing wildlife screening benchmarks (ES/ER/TM-86/R3). The surrogate soil-indicator concentrations were developed using the lowest of the LOAELs (or NOAELs, where an LOAEL was unavailable) from the ORNL dataset. Because these toxicity reference values typically were compiled from data collected on small mammals under laboratory exposures, there is uncertainty as to whether they over- or under-represent actual toxicity of the chemicals to the receptors of concern identified for the 200-CS-1 OU sites.

Toxicity information from a more thorough search of the scientific literature and other databases could be used to develop additional screening levels for the receptor species modeled in WAC 173-340-900. It could be possible to reduce uncertainty and eliminate additional COPECs for the 200-CS-1 OU sites based on a larger set of screening criteria. Literature searches were not performed; instead, the toxicity compilations developed by ORNL were used in the methodology described in WAC 173-340-900 as a sufficiently conservative approach to developing criteria.

3.5.4.5 Nutrients and Natural Elements

Some of the COPECs retained for the 200-CS-1 OU sites include general inorganic compounds naturally occurring in soils, such as ammonia, nitrate, nitrite, phosphate, sulfide, and sulfate. Although these compounds were measured at some of the sites at concentrations above background values, they may not represent a potential threat to ecological receptors unless average concentrations are substantially higher than the range of background concentrations. For this SLERA, only the maximum concentrations were compared with the 90^{th} percentile of background concentrations to determine whether they should be retained for further consideration. A full evaluation of the potential for contamination above background would reduce the uncertainty of the potential risk from these compounds. Other chemicals were screened out as nutrients and natural soil chemicals that were considered not to pose an ecological risk, such as calcium and magnesium.

3.5.4.6 Summary of Uncertainty Analysis

Overall, the SLERA performed for the 200-CS-1 OU sites was a conservative screening process designed to avoid underestimating potential risks to wildlife. The incorporation of conservative assumptions into the toxicity reference values and exposure parameters, and the use of maximum concentrations as the exposure-point concentrations, were factors in ensuring that the SLERA followed a conservative approach. Potential ecological risks, noted as exceedances of screening criteria, were identified for numerous chemicals based on the SLERA, which were not further evaluated or refined beyond the screening process. The COECs identified for the sites are considered sufficiently conservative to represent those chemicals that may pose ecological risks at the site, and the potential ecological risks are unlikely to be underestimated by the SLERA process.

3.6 GROUNDWATER-PROTECTION PATHWAY

The purpose of this section is to evaluate potential degradation of the aquifer from contamination remaining in the waste sites and in the vadose zone beneath those waste sites. The general approach for evaluating nonradionuclides and radionuclides at each waste site is illustrated in Figure 3-6. A series of steps described in Section 3.3 were used to select the groundwater-protection pathway COPCs. The potential impacts of these COPCs then were assessed through a model of the site developed using the RESRAD code for radiological COPCs and through a comparison of maximum waste-site concentrations to the WAC-173-340-747, "Deriving Soil Concentrations for Groundwater Protection" cleanup levels for nonradiological COPCs.

3.6.1 Nonradionuclide Groundwater-Protection Pathway Evaluation

Evaluation of the groundwater-protection pathway for nonradiological COPCs includes a comparison of maximum detected concentrations to the WAC 173-340-747 groundwater protection cleanup levels.

3.6.1.1 WAC 173-340-747 Groundwater-Protection Cleanup Levels

Groundwater protection cleanup levels are based on the WAC 173-340-747 fixed-parameter three-phase equilibrium partitioning model (hereinafter referred to as the three-phase model). The equation used to derive the three-phase model cleanup levels for groundwater protection is described by the following equation:

$$C_s = C_w (UCF) DF \left[K_d + \frac{(\theta_w + \theta_a H_{cc})}{\rho_b} \right]$$

where,

C_s = soil concentration (mg/kg)

C_w = groundwater cleanup level (µg/L)

UCF = unit conversion factor (1 mg/1000 µg)

DF = dilution factor (20)

K_d = distribution coefficient (L/kg)

θ_w = water-filled soil porosity (0.3)

θ_a = air-filled soil porosity (0.13)

H_{cc} = Henry's law constant

ρ_b = dry bulk soil density (1.5 kg/L).

Chemical-specific parameter values used in the calculation of the groundwater protection cleanup levels are provided in Appendix F. Unless otherwise specified, the groundwater cleanup levels are calculated from the more conservative of Equation 720-1 or 720-2 from WAC 173-340-720 ("Groundwater Cleanup Standards"), and the distribution coefficients (K_d) and Henry's law constants (H_{cc}) values were obtained from CLARC Version 3.1 (Ecology, 2005). If values were not available in CLARC 3.1, then the K_d and H_{cc} values were assumed to be zero (see Appendix F).

Note that default K_d values obtained from the CLARC tables may not correspond with values estimated or measured in Hanford Site soils. The use of default values obtained from the CLARC tables may either over- or underestimate the concentration of contaminant that is protective of groundwater. However, in some cases when the K_d value was not reported in CLARC, a site-specific K_d value was used. The dilution factor in the three-phase model is calculated as the sum of the volumetric infiltration and groundwater flow rates (cubic meters per year) divided by the volumetric infiltration flow rate. The default value of 20 implies that groundwater flow volume beneath a site is about 20 times greater than the volume of vadose-zone water infiltrating groundwater at the site. Considering aquifer flow rates and recharge rates for the 200 Areas, the default value of 20 is a minimum value for dilution at these sites.

3.6.1.2 Comparison of Sample Results to Groundwater Protection Cleanup Levels

Tables 3-10a through 3-10d summarize the comparison of maximum detected concentrations of COPCs from the entire soil column to the WAC 173-340-747 cleanup levels.

For several metals, the WAC 173-340-747 cleanup level is less than the Hanford Site 90th percentile background value. When cleanup levels were less than the background value, sample results were compared to the background value.

216-A-29 Ditch. A comparison of maximum detected concentrations from the 216-A-29 Ditch to the WAC 173-340-747 cleanup levels is provided in Table 3-10a. Five metals (arsenic, cadmium, mercury, silver, and uranium), nitrate as N, two PAHs, Aroclor-1254, and four volatile organic compounds (1,2-dichloroethane, methylene chloride, tetrachloroethylene, and tributyl phosphate) were reported with maximum detected concentrations above the groundwater protection cleanup levels. As noted in Table 3-10a, a few other chemicals were detected but did not have cleanup levels for comparison. Test Pit AD-1 from 1.2 to 1.5 m (4 to 5 ft), soil-boring 8826 from 1.2 to 1.8 m (4 to 6 ft), and test pit AD-2 from 2.3 to 2.6 m (7.5 to 8.5 ft) were the primary locations where contaminant concentrations were above groundwater protection cleanup levels.

216-B-63 Trench. A comparison of maximum detected concentrations from the 216-B-63 Trench to the WAC 173-340-747 cleanup levels is provided in Table 3-10b. Cadmium, nitrate as N, Aroclor-1260, benzene, and methylene chloride were reported with maximum detected concentrations above their groundwater-protection cleanup levels. As noted in Table 3-10b, a few other chemicals were detected but did not have cleanup levels for comparison. Soil-boring 8827 from 3 to 4.1 m (10 to 13.5 ft) and soil-boring E33-333 from 2.4 to 4.7 m (8 to 15.5 ft) were the primary locations where contaminant concentrations were above groundwater-protection cleanup levels.

216-S-10 Ditch. A comparison of maximum detected concentrations from the 216-S-10 Ditch to the WAC 173-340-747 cleanup levels is provided in Table 3-10c. Three metals (cadmium, mercury, and silver), Aroclor-1254, and six PAHs were reported with maximum detected concentrations above the groundwater-protection cleanup levels. As noted in Table 3-10c, a few other chemicals were detected but did not have cleanup levels for comparison. Test Pit SD-2 from 0 to 0.9 m (3 ft) was the primary location where contaminant concentrations were above groundwater-protection cleanup levels.

216-S-10 Pond. A comparison of maximum detected concentrations from the 216-S-10 Pond to the WAC 173-340-747 cleanup levels is provided in Table 3-10d. Methylene chloride was reported with a maximum detected concentration above its groundwater-protection cleanup level. As noted in Table 3-10d, a few other chemicals were detected but did not have cleanup levels for comparison.

3.6.2 Radionuclide Groundwater-Protection Pathway Evaluation

The evaluation of the groundwater-protection pathway for radiological contaminants requires the use of a model to predict the movement of contaminants through the soil column into groundwater. As discussed in Section 3.4.2, the RESRAD code was selected to perform these analyses based on its acceptance for use by the EPA. The EPA determined that RESRAD was suitable for use at radiological cleanup sites, because it meets a series of exposure-pathway analysis criteria.

A simplified conceptual site model is developed for each representative waste site, as the RESRAD code uses typical convection and dispersion equations to represent flow and transport through the vadose zone (ANL, 2005). The simplified conceptual site models developed for use with the RESRAD code were developed using the waste-site conceptual model and site-geology information presented in Sections 3.2,2.3 and 2.4 of this report. A detailed description of how the simplified conceptual site models were developed for each representative waste site, the basis for selection of the RESRAD code input parameters, and the results of the analysis are presented in Appendix E. Note that the need for a more detailed alternative fate-and-transport modeling approach was considered, but due to the limited amount of information, was not attempted and likely would be consistent with the outcome of the RESRAD analysis for this OU.

3.6.2.1 Development of Conceptual Site Model(s)

The 200-CS-1 OU background, history, and physical features are presented in Sections 2.3 and 2.4 and describe the contaminant sources and the geological features and processes that dominate contaminant transport to groundwater. The simplified conceptual site models developed for the waste-site modeling are consistent with this information. The conceptual site models for the groundwater-protection pathway include many factors that affect fate and transport. The simplified conceptual site models developed for this analysis were designed to capture the site features, future events, and hydraulic and chemical processes that dominate the transport of contaminants to the groundwater. Previous studies (e.g., "Quantifying the Effects of Small-Scale Heterogeneities on Flow and Transport in Undisturbed Cores from the Hanford formation," [Pace et al., 2004]; "Evidence of Stratigraphic Control of Field-Scale Moisture Dynamics Based on Spatial Movement Analyses and Anisotropy in the Spatial Correlation Scale," [Ward et al., 2005]; DOE/ORP-2000-24, *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version*) provide the basis for identifying the features and processes that are not included in the simplified conceptual site models, because they are not dominant features for mass flux to groundwater.

For each representative waste site, the distribution of contaminants throughout the soil column is based on current conditions as represented by field characterization and sample-analysis results. Past discharges have been redistributed in the soil column, and much of the liquid has drained from the soil column. Because the soil column has drained, water from these past discharges is not expected to affect future transport. Additionally, inventory discharged to these waste sites was not characterized during operations. Therefore, inventory and distribution of contaminants at the start of the analysis (initial condition) are based on available field-characterization data.

The simplified conceptual site models assume that the soil contamination is present in layers below the surface, with each layer having a uniform concentration of the contaminants. As a result of the limited amount of analytical results collected at each waste site, the maximum concentration was ascribed uniformly to the entire layer. This approach likely will result in an overestimation of the actual inventory on an areal basis (throughout the waste site and vadose zone). Additionally, characterization data for each waste site were collected using a biased sampling design intended to represent worst case contaminant conditions. As a result, this analysis likely will overestimate contaminant concentrations in groundwater.

As indicated in Chapter 2.0, available site data provide limited information on the variation in contaminant concentration and vadose-zone properties in three dimensions. As a result, a one-dimensional model was used to analyze the potential impacts to groundwater.

The conceptual site models discussed in Section 3.2 indicate that water and contaminants may have spread laterally in the vadose zone beneath these waste sites, especially in areas with layers of fine-grained sediment or at facilities that received a large amount of effluent. Lateral spreading is an element of the conceptual model that is not explicitly represented in this analysis. As noted in PNNL-14702, Rev. 1, *Vadose Zone Hydrogeology Data Package for Hanford Assessment*, the omission of small-scale stratifications and variations in texture likely will lead to an underestimation of the effects of lateral spreading. This is expected to overestimate the rate that contaminants move toward groundwater, as well as overestimating the concentration of the contaminants as they reach groundwater. This overestimation occurs because a reduced cross sectional area of flow is used, and a smaller volume of sediments is contacted by the contaminants. Thus, by not explicitly including lateral spreading in this analysis, the impact to groundwater likely will be overestimated.

The analysis that is conducted for each waste site calculates a concentration in groundwater immediately below the waste site. The concentration calculated subsequently is compared to the Federal maximum contaminant level as the metric to determine the potential for degradation of groundwater.

3.6.2.2 Description of the 200-CS-1 Operable Unit Representative Waste Sites

The RESRAD software requires the soil column to groundwater to be represented using four layers. Therefore, the soil column to groundwater at each waste site was divided into four discrete layers based on the geology of the site and the contaminant distribution observed at the respective waste site. The top layer is an uncontaminated cover soil, the second layer is contaminated soil, the third layer is the unsaturated zone (or vadose zone), and the fourth layer is the saturated zone, or aquifer. The vadose zone can be divided into as many as five sublayers.

Although WAC-173-340 describes the shallow zone as soil depths ranging from 0 to 4.6 m and the deep zone as soil depths ranging from 4.6 m to the groundwater table, the RESRAD model is limited to evaluating a single contaminated layer per run (i.e., upper layer or lower layer). As described below for each waste site, the upper layer of contamination was not limited to the top 4.6 m, and the lower layer of contamination was not equally distributed from 4.6 m to the groundwater table. To account for these site-specific differences, the shallow zone (or upper layer) of contamination was extended to the depth where contamination was observed. Similarly, the deep zone (or lower layer) of contamination reflects the depth(s) where contaminants were observed. These site-specific depths were used as the contaminated zone in RESRAD. These layers are summarized below (and described in more detail in Appendix E). The waste-site dimensions for each representative waste site are presented in Table E-10 of Appendix E.

216-A-29 Ditch. All of the measured activity (with the exception of tritium) appears to be in the top 6 m (20 ft) of soil at the 216-A-29 Ditch. Samples taken from 5.9 to 6.7 m (19.5 to

22 ft) showed no man-made activity. Tritium concentrations were not detected to the sample depth of 45.7 to 46.3 m (150 to 152 ft). Measurable contamination was detected in the sample taken at 61 to 61.6 m (200 to 202 ft). Thus, the tritium appears to be confined to a thin layer deep in the vadose zone. However, in the RESRAD soil model, the tritium will be represented as uniform throughout a thicker layer extending from 53.3 m (175 ft) below the surface down to the aquifer at 82.3 m (270 ft). The tritium concentration in this layer is the maximum found; 7.05 pCi/g. Thus, the soil model for the 216-A-29 Ditch has two contaminated layers, the upper layer starting below the cover from 1.2 to 6.1 m (4 to 20 ft) and the deeper layer from 53.3 to 82.3 m (175 to 270 ft). The activity concentration in each layer is listed in Table E-10 of Appendix E.

Because the vadose zone and stratigraphic thicknesses beneath the 216-A-29 Ditch vary over its approximate 1,220 m (4,000 ft) length, two separate soil columns were prepared representing the head end of the ditch and the outlet. An example of how the vadose-zone geology described in Section 2.4 and the contaminant distribution beneath the head end of the 216-A-29 Ditch is represented in the RESRAD analysis is presented in Figure E-1 in Appendix E. Similar figures for each of the representative waste sites analyzed are included in Appendix E. Each layer in the model is assumed to have a uniform concentration at the maximum value observed in that layer.

216-B-63 Trench. All of the measured activity appears to be in the top 7.6 m (25 ft) of soil at the 216-B-63 Trench. Samples taken at 7.3 to 7.6 m (24 to 25 ft) and below showed no man-made activity with the exception of Ni-63. However, samples were taken only to a depth of 31.4 m (103 ft), and the soil column extends to 74.7 m (245 ft). The Ni-63 concentrations were greatest in the upper 7.6 m (25 ft), but lower concentrations of Ni-63 were measured all the way to the lowest depth sampled. By simple extrapolation, the absent Ni-63 concentration between 31.4 m (103 ft) and the groundwater (74.7 m [245 ft]) will be represented by the maximum value found between 7.6 and 31.4 m (25 and 103 ft), namely 5.68 pCi/g. Thus, the soil model for the 216-B-63 Trench has two contaminated layers; the upper layer starting below the cover is from 1.5 to 7.6 m (5 to 25 ft), and the lower layer is from 7.6 to 74.7 m (25 to 245 ft). The activity concentration in each layer is listed in Table E-10 of Appendix E.

216-S-10 Ditch. All of the measured activity appears to be in the top 9.1 m (30 ft) of soil at the 216-S-10 Ditch. Samples taken below 8.2 m (27 ft) showed no man-made activity, with the exception of Ni-63. The Ni-63 concentration is not detected in the 15.2 to 15.8 m (50 to 52-ft), 30.5 to 31.1 m (100 to 102-ft), 41.1 to 41.8 m (135 to 137-ft), and 67.1 to 67.7 m (220 to 222-ft) samples. Measurable concentrations were observed in the 45.7 to 46.3 m (150 to 152-ft), 56.4 to 57 m (185 to 187-ft), and 61 to 61.6 m (200 to 202-ft) samples. Hence, the Ni-63 contaminated deep zone will be represented by a soil layer ranging from 42.7 to 64 m (140 to 210 ft) below the surface. The activity concentration in this layer is the maximum observed, namely 10.7 pCi/g. Thus, the soil model for the 216-S-10 Ditch has two contaminated layers, the upper layer is from 0.6 to 9.1 m (2 to 30 ft), and the lower layer is from 42.7 to 64 m (140 to 210 ft). The activity concentration in each layer is listed in Table E-10 of Appendix E.

216-S-10 Pond. At the 216-S-10 Pond, all of the samples are from depths above 7.9 m (26 ft) and from depths below 10.7 m (35 ft). All of the measured activity (except for Ni-63, Sr-90, and Pu-239) appears to be in the top 9.1 m (30 ft) of soil. The sample taken at 15.2 to 15.8 m (50 to 52 ft) contained some Ni-63 and Sr-90. Also, the sample at 30.3 to 30.9 m (99.5 to 101.5 ft) showed a small Pu-239 contamination. However, samples at 10.7 to 11.3 m (35 to 37 ft), 41.1 to 41.8 m (135 to 137 ft), 45.7 to 46.3 m (150 to 152 ft), 54.9 to 55.5 m (180 to 182 ft), and 60 to 60.7 m (197 to 199 ft) had no man-made activity. Hence, the Ni-63 and Sr-90 contamination is represented as extending from 13.4 to 23.2 m (44 to 76 ft) below the surface. The Pu-239 contamination is represented as extending from 23.2 to 36 m (76 to 118 ft) below the surface.

In summary, the soil model for the 216-S-10 Pond representative waste site has three contaminated soil layers. The upper layer starting below the cover is from 1.8 to 9.1 m (6 to 30 ft), the first deep layer is from 13.4 to 23.2 m (44 to 76 ft), and the second deep layer is from 23.2 to 36 m (76 ft to 118 ft). The activity concentration in each layer is listed in Table E-10 of Appendix E.

3.6.2.3 RESRAD Input Parameters

RESRAD requires the input of parameters related to the hydraulic and geochemical properties of each soil layer. Hydraulic properties (and input parameters) were assigned to each of the hydrostratigraphic layers by matching them to the soil hydraulic-property classes described in PNNL-14702, Rev. 1. The hydrostratigraphic thicknesses and soil classes associated with each representative waste site are summarized in Table E-11 of Appendix E. The hydrostratigraphic layers represented in this table were defined based on the geologic and hydrogeologic data described in the RI (DOE/RL-2004-17) and in other pertinent site-specific documents such as PNNL-13047, *Groundwater Monitoring Plan for the 216-A-29 Ditch*, Section 2.0. The hydraulic properties such as soil-bulk density, porosity, residual moisture, K_{sat}, distribution coefficient (K_d), and "b" parameter selected for each of the waste sites are listed in Table E-12 of Appendix E. The sources of this information are provided in detail in Appendix E.

The radionuclide COPCs were identified in the data-evaluation phase described in Section 3.3 and are shaded grey in Table 3-11. The concentrations of these COPCs were input to RESRAD.

3.6.2.4 Summary of RESRAD Groundwater Concentrations

Each contaminated soil layer was run as a separate case in RESRAD. Although RESRAD allows a maximum simulation time of 100,000 years, the maximum time period was limited to 10,000 years. The principal reason for this limit is the uncertainty associated with future climate.

Extra RESRAD cases were run to find the maximum groundwater concentration during the first 10,000 years. Peak concentrations for those contaminants that reached groundwater in 10,000 years are listed in Table 3-12. Contaminants that did not reach groundwater, and small contributions from progeny nuclides such as U-233 that are produced by the decay of the parent, are not shown.

216-A-29 Ditch. The graphical output for the H-3 groundwater concentrations at the head of the 216-A-29 Ditch is shown in Figure 3-7. Tritium is the only contaminant predicted to reach groundwater, based on soil properties observed near the head of the 216-A-29 Ditch. Tritium was only analyzed in the B8826 borehole, with the highest concentrations measured from 79.2 to 79.9 m (260 to 262 ft) bgs (7.05 pCi/g) and from 82.9 to 83.5 m (272 to 274 ft) bgs (1.63 pCi/g). The peak tritium concentration of 1,300 pCi/L is predicted to reach groundwater in 20 years (A.D. 2027) and is below the Federal maximum contaminant level of 20,000 pCi/L.

The graphical output for U-234 and U-238 groundwater concentrations are shown in Figures 3-8 and 3-9, respectively. The U-234 and U-238 isotopes are predicted to reach groundwater in 5,174 years, based on soil properties near the outlet of the ditch, while the isotopes are not predicted to reach groundwater using the soil properties at the head of the ditch. Because the EPA drinking water standard (maximum contaminant level) for uranium is given as a mass concentration, the activity concentrations of the main isotopes of uranium were converted from activity to mass using the specific activities listed in Appendix E. As shown, the total uranium concentration of 1,170 μg/L is considerably above the Federal drinking water maximum contaminant level of 30 μg/L.

U-234 was detected in all four samples, with concentrations ranging from 0.33 to 2.3 pCi/g. The maximum U-234 concentration of 2.3 pCi/g was measured at Test Pit AD-2 from 2.3 to 2.6 m (7.5 to 8.5 ft) bgs. All remaining U-234 concentrations were less than Hanford Site background levels. Although U-234 is present at one location above background, it contributes an insignificant amount to the total uranium concentrations predicted to reach groundwater. However, it should be noted that only four samples were collected from this waste site and analyzed for U-234.

U-235 was detected in three of 28 samples, with concentrations ranging from 0.061 to 0.44 pCi/g. The maximum U-235 concentration of 0.44 pCi/g was measured at Test Pit AD-1 from 1.2 to 1.5 m (4 to 5 ft) bgs. All remaining concentrations were less than the 90th percentile Hanford Site background level of 0.11 pCi/g.

U-238 was detected in six of 36 samples, with concentrations ranging from 0.5 to 1.8 pCi/g. The maximum U-238 concentration of 1.8 pCi/g was measured at Test Pit AD-2 from 2.3 to 2.6 m (7.5 to 8.5 ft) bgs. All remaining U-238 concentrations were less than the 90th percentile Hanford Site background level of 1.1 pCi/g.

No other contaminants measured at the 216-A-29 Ditch were predicted to reach groundwater within the 10,000-year time period.

216-B-63 Trench. The graphical output for Tc-99 groundwater concentrations is shown in Figure 3-10. Tc-99 is the only contaminant predicted to reach groundwater at the 216-B-63 Trench. The peak Tc-99 concentration of 185 pCi/L is predicted to reach groundwater in 2,273 years (A.D. 4280) and is below the Federal maximum contaminant level of 900 pCi/L.

Tc-99 was detected in only one of 25 samples analyzed. Tc-99 was detected at a concentration of 0.41 pCi/g in borehole B8827 from 5.3 to 5.8 m (17.5 to 19 ft) bgs.

No other contaminants measured at the 216-B-63 Trench were predicted to reach groundwater within the 10,000-year time period.

216-S-10 Ditch. No contaminants measured at the 216-S-10 Ditch were predicted to reach groundwater within the 10,000-year time period.

216-S-10 Pond. The graphical output for the C-14 groundwater concentration near the 216-S-10 and 216-S-11 Ponds is shown in Figure 3-11. C-14 is the only contaminant predicted to reach groundwater at the 216-S-10 Pond. The peak C-14 concentration of 8,260 pCi/L is predicted to reach groundwater in 1,323 years (A.D. 3330). As shown in Table 3-12, the peak concentration of 8,260 pCi/L is above the Federal maximum contaminant level of 2,000 pCi/L. C-14 was detected only at Test Pit SP-2, at a concentration of 12.2 pCi/g, from 2 to 2.3 m (6.5 to 7.5 ft) bgs.

Based on the simple (and conservative) models used in this analysis, only the uranium isotopes at the 216-A-29 Ditch and the C-14 at the 216-S-10 Pond may exceed the Federal drinking water standards in the future.

3.6.3 Uncertainty Analysis for the Groundwater-Protection Pathway

The purpose of the BRA is to identify and characterize potential risks and hazards to the environment. These findings are used in the FS to select appropriate remedies to reduce risks to target cleanup goals established by the EPA and State of Washington. Estimating and evaluating risks from exposure to environmental contaminants is a complex process with inherent uncertainties. Uncertainty reflects limitations in knowledge and simplifying assumptions that must be made to quantify health risks. Underestimation or overestimation of risk can lead, respectively, to failure to remediate true hazards, or unnecessary cleanup and expense.

The following uncertainty discussion concludes that the sampling strategy employed in the RI, coupled with strict adherence to CERCLA and *Washington Administrative Code* guidance, results in risk determinations that are more likely overestimated than underestimated. In addition, it is important to note that the biased sampling targeted worst-case/maximum concentrations at the expense of fully characterizing each site. As a result, the risk assessment is based on limited data and a relatively high degree of uncertainty and purposefully avoids false-negative risk conclusions. It is anticipated that additional sampling will be incorporated in the remedial design/remedial action process to better characterize the site and to address the more likely false-positive errors.

In this assessment, the major uncertainties relate to the following:

- Development of representative media concentrations
- Assumptions about RESRAD modeling.

3.6.3.1 Data Collection and Media Concentrations

Risk assessment depends heavily on the quality and the representative nature of the sampling data. The RI sampling strategy could lead to either overestimation or underestimation of risk. For this assessment, the quality of the data was determined to be high, but the representativeness was limited. Understanding the genesis of the sampling strategy is useful to evaluating the resultant uncertainties.

The nonstatistical sampling protocol employed was preferentially biased toward encountering the worst case conditions/maximum concentrations of contaminants. The maximum values obtained from these sample locations then were used to characterize large exposure units. For example, the 216-A-29 Ditch is nearly a mile long. Samples were collected from six independent sample locations within the ditch and one deeper zone location. The maximum concentration observed at any depth was used to characterize the entire volume of soil either to a maximum depth to which the contaminant was observed or from 0 to 4.6 m and 4.6 m to groundwater. This exposure unit becomes the remediation unit for the FS. This likely overestimates the extent of subsurface contamination, potentially identifying some areas as hazardous that are, in fact, at lower concentrations. This more likely leads to overestimation of risk for the entire exposure unit and to false-positive identification of potential remediation units as hazardous, for evaluation in the FS.

3.6.3.2 Modeling

The uncertainty inherent in the RESRAD model (ANL, 2005) contributes to the overall estimation of human-health risk and impacts to groundwater. RESRAD was used to model both the human-health industrial scenario for radionuclides and the simplified fate-and-transport modeling to determine COPCs. Fate-and-transport modeling in RESRAD is a simplified one-dimensional model generally designed to err on the conservative side. In general, RESRAD likely contributes to false-positive results for the groundwater-protection pathway outcome. Other potential uncertainty can result from parameter selections in implementing the model. Critical parameter selections made in this analysis include distribution coefficients, dilution factors, hydrogeologic characterizations, site dimensions, cover and backfill conditions, indoor/outdoor partitions, and anticipated worker activities.

Because these parameters often are multiplicative and are used in nonlinear predictions, the uncertainty is compounded in the model. As a result, selecting conservative values for all parameters likely would result in highly improbable outcomes. This usually is addressed by selecting central-tendency values in addition to RME values for the model runs. Uncertainties then are assessed by sensitivity analyses. Individual parameters are modified to more and less conservative values, and the changes in outcomes are assessed to identify the most sensitive parameters. Variability and uncertainty in those parameters then are presented qualitatively. Sensitivity analyses were not conducted with these results. One of the underlying goals of the modeling in this assessment was to determine whether the groundwater-pathway evaluation could be improved by more sophisticated model applications. Because of the limited characterization data available for these sites, the conclusion of the groundwater evaluations was that additional modeling would not significantly augment the knowledge base for the risk managers.

The endpoint of the groundwater-protection analysis is a comparison to a metric that has been established to indicate degradation of groundwater. The concentration calculated is compared to the Federal maximum contaminant level as the metric to determine the potential for degradation of groundwater.

3.7 RISK-ASSESSMENT SUMMARY AND IMPLICATIONS FOR THE FEASIBILITY STUDY

Tables 3-13a through 3-13d summarize the COCs identified from the SLERA and groundwater-protection pathway evaluation. The human health risk assessment did not identify any COCs greater than acceptable risk criteria (i.e., CULs for nonradionuclides, doses greater than 15 mrem/y or excess lifetime cancer risks greater than 10^{-5} and for radionuclides). The uncertainty associated with this BRA is summarized in Section 3.7.2 below, and uncertainty discussions specific to each risk assessment are presented above.

The COCs shown in Tables 3-13a through 3-13d were further evaluated to determine risk drivers and implications for the FS. Exceedance factors (EF) calculated for each of the COCs are also shown in Tables 3-13a-d. EFs were calculated by dividing the waste site's maximum detected concentration by the higher of the background or risk criteria. Typically, COCs with the greatest EFs are considered risk drivers. Not all COCs or COECs were identified as risk drivers (i.e., risk drivers are those COCs that, when evaluated independently, would trigger a remedial action).

COCs based on the groundwater-protection pathway were considered priority to the COECs. This is because, although deemed appropriate for this analysis, COECs were based on a screening level ecological risk assessment and this screening level evaluation will be supplemented in the future with the larger Hanford Site ecological risk assessment currently under development.

Most of the metals identified as COCs/COECs were within a range of a few mg/kg of the background concentration. In some cases, background concentrations are not known, or not well characterized. Several of the COCs and COECs with maximum concentrations near background levels (i.e., those with low EF values) were eliminated as risk drivers, as discussed below.

For example, Figure 3-12 illustrates all observed waste site concentrations for selenium in comparison to the background and toxicity criteria. Only a few samples exceeded the estimated State background level; none were more than 2 mg/kg above the estimated background value of 0.78 mg/kg and all samples were well below the groundwater-protection pathway CUL. The lognormal 90th percentile selenium background concentration used to compare to waste site concentrations was estimated from 14 samples from the State survey (Ecology 94-115). This background level also exceeds the terrestrial soil indicator value used for the SLERA. As a result, selenium was not considered a risk driver because the highest concentrations observed were well below the groundwater-protection pathway CUL and close to a poorly characterized background level that exceeds the SLERA criteria. For these reasons, selenium was disregarded as a risk driver for the FS.

Similarly, no background value was estimated for thallium from either the Hanford Site survey (DOE/RL-92-24) or the State survey (Ecology 94-115). The level of detection in those surveys ranged from 3.7 mg/kg to 5 mg/kg, respectively, and no background samples were above these levels of detection. Figure 3-13 shows that the detected results for thallium at the 200-CS-1 OU waste sites ranged from approximately 0.5 to 1 mg/kg, all well below the groundwater-protection pathway CUL of 1.6 mg/kg. The thallium minimum quantification limits ranged from approximately 0.1 to 0.3 mg/kg, which exceeds the terrestrial soil indicator value of 0.16 mg/kg. This thallium issue is not unique to the 200-CS-1 OU and is likely observed other Hanford OUs. As a result, thallium was disregarded as a risk driver for the FS.

Other metals identified as COCs or COECs were not identified as risk drivers if all the results for a particular sample location and depth ranged within a few mg/kg of the background value (typically less than 2 times background concentrations). These metals included arsenic, cadmium, chromium, silver, mercury, and uranium. In a few cases these same metals were considered risk drivers at other locations where larger EFs were noted and the metals were co-located with other COCs/COECs. These exceptions are noted below in Section 3.7.1. Figures 3-14 through 3-17 illustrate the range of concentrations and background and risk criteria for cadmium, silver, arsenic and chromium, respectively. Uranium was disregarded as a risk driver at one site where total uranium and all isotopes detected were slightly above background concentrations.

In general, when concentrations from analytes considered common laboratory contaminants were qualified due to associated laboratory blank contamination (i.e., qualified with a "B"), these were not considered risk drivers. In addition, DOE does not consider nitrate an independent risk driver; it must be co-located with another COC that requires cleanup to be considered a risk driver. Some of the detected nitrate concentrations exceeding CULs are co-located with other COCs/COECs or risk drivers, as noted in the discussion below.

3.7.1 Summary of Risk Determinations by Waste Site

The following sections summarize the outcome of the BRA by waste site and sample location and discusses risk drivers and EFs.

3.7.1.1 Summary at 216-A-29 Ditch

A summary of the 216-A-29 Ditch COCs and COECs and their sample locations and depths with contaminant concentrations above their respective CULs is provided in Table 3-13a. As shown, test pit AD-1, soil boring B8826, and test pit AD-2 are the primary locations with contaminant concentrations above groundwater-protection pathway CULs and ecological indicator values or BCGs. The COCs considered risk drivers associated with the groundwater-protection pathway include inorganic metals (cadmium); organic solvents, PCBs, PAHs and tributyl phosphate. Additional contaminants considered risk drivers identified in the SLERA include silver, Cs-137 and bis(2 ethylhexyl)phthalate.

Test Pit AD-1. Five depth intervals were collected from this location with depths ranging from 1.2 to 4.6 m (4 to 15 ft bgs). The sample collected from 1.2 to 1.5 m (4 to 5 ft) bgs showed some contamination. Cadmium (EF=28) was identified as a risk driver for the groundwater-protection pathway and was co-located with the following COCs; mercury (EF=2.5), and silver (EF=3.1). Additional organic chemicals considered risk drivers were Aroclor-1254 (EF=7.2), two PAHs (benzo(a)anthracene (EF=2.1) and chrysene (EF=2.2)); and two volatile organic compounds (1,2-dichloroethane (EF=5.6) and tetrachloroethylene (EF=6.9)). Silver (EF=10) and Aroclor-1254 (EF=2.9) were also identified as ecological risk drivers as were bis(2 ethylhexyl)phthalate (EF=7.3) and Cs-137 (EF=4.9).

Sulfate (EF=3.0) and nitrate (EF=1.2) also exceeded groundwater-protection pathway CULs or background, but were not retained as independent risk drivers. With the exception of arsenic reported slightly above the 90th percentile background concentration at 2.0 to 2.3 m (6.5-7.5 ft) bgs and 2.7 to 3.0 m (9-10 ft) bgs (see Figure 3-16 and Table 3-13a), no other contaminants are present above the groundwater-protection pathway CULs at any other depth from this location. Arsenic and selenium were not considered risk drivers as discussed above. Methylene chloride was dismissed as a risk driver because it was detected in that sample's associated blank. Dibutyl phthalate was not considered an independent risk driver, however, it is co-located with several risk drivers at the location and depth.

Soil Boring B8826. Thirteen depth intervals were collected from this location with depths ranging from 1.2 to 83.5 m (4 to 274 ft) bgs. Risk drivers for the groundwater-protection pathway were identified for the sample collected from 1.2 to 2.0 m (4 to 6.5 ft) bgs and were cadmium (EF=5.3), Aroclor-1254 (EF=1.9), and tributyl phosphate (EF=17). With the exception of cadmium reported slightly above background at 2.7 to 3.5 m (9-11.5 ft) bgs, and methylene chloride reported at 79.2 to 79.9 m (260 to 262 ft) bgs, no other contaminants are present above the groundwater-protection pathway CULs at any depth from this location. The cadmium concentrations at 2.7 to 3.5 m (9-11.5 ft) bgs was dismissed as a risk driver because it was within a few mg/kg of background and was the only contaminant observed at this depth. The latter two were dismissed due to the relatively low EFs and the deep depth interval.

Test Pit AD-3. Six depth intervals were collected from this location with depths ranging from 1.8 to 5.1 m (6 to 17 ft) bgs. Arsenic and thallium were the only COC/COECs identified and all were dismissed as risk drivers as discussed above. The samples collected at 1.8 to 2.1 m (6 to 7 ft) bgs and 2.6 to 2.9 m (8.5 to 9.5 ft) bgs were reported with concentrations of arsenic greater than terrestrial soil indicator values or CULs (see Table 3-13a). However, these arsenic concentrations are only slightly above and within a few mg/kg of the background level (see Figure 3-16). No other contaminants are present above the groundwater-protection pathway CULs at any depth from this location.

Area 9. Three depth intervals were collected from this location with depths ranging from 1.2 to 3.0 m (4 to 10 ft) bgs. No contaminants are present above their respective groundwater-protection pathway CULs at any depth from this location. It should be noted that samples from this location were not analyzed for volatile organic compounds. Selenium was identified as a COEC, but as described above, is not considered a risk driver.

Area 8. Six depth intervals were collected from this location with depths ranging from 0.9 to 4.9 m (3 to 16 ft) bgs. The sample collected at 4 m (13 ft) bgs was reported with cadmium slightly above the background value of 1 mg/kg but cadmium is not considered a risk driver as described above. No other contaminants are present above the groundwater-protection pathway CULs at any depth from this location. It should be noted that samples from this location were not analyzed for volatile organic compounds. Similar to Area 9, selenium was a COEC but not considered a risk driver.

Test Pit AD-2. Six depth intervals were collected from this location with depths ranging from 1.5 to 4.9 m (5 to 16 ft) bgs. Arsenic was identified with an EF=1.2 at 1.5 to 1.8 m (5 to 6 ft) bgs and was not considered a risk driver. The sample collected from 2.3 to 2.6 m (7.5-8.5 ft) bgs showed COCs (cadmium (EF=2.3), mercury (EF=2.1), total uranium (EF=1.6), methylene chloride (EF=1.1), U-233/234 (EF=2.1), and U-238 (EF=1.7)) for the groundwater-protection pathway. Lead (EF=3.3), selenium (EF=1.8), silver (EF=1.6) and vanadium (EF=1.2) were identified as additional COECs from the SLERA (see Table 3-13a). All of these metals and radioisotopes were not considered risk drivers because the observed concentrations were near background levels. Methylene chloride at this depth was considered a laboratory contaminant because it was detected in the associated blank. The results of the RESRAD analysis for U-233/234 and U-238 detected at this location indicated that the uranium mass concentration (mostly U-238) in groundwater exceeded the maximum contaminant level of 30 μg/L and was therefore shown as a COC. However, the representative concentration in soil of U-238 (1.81 pCi/g) is only slightly above the lognormal 90th percentile background concentration. Additional analysis using the background soil concentration indicated that the uranium mass concentration would also exceed the maximum contaminant level (30 μg/L) at background soil concentrations. Similar to the nonradionuclides when a CUL or soil indicator value for a radionuclide was less than background, the background concentration was used to calculate the EF. Therefore, EFs for these uranium results at this location were based on the ratio of site maximum concentrations to the background concentration. Similar to the metals that were within a few mg/kg of the background concentrations, U-233/234 and U-238 were within 1.2 pCi/g of background concentrations and were not considered risk drivers. It should also be noted that the RESRAD results are highly dependent on the K_d values that were used for uranium; 0.8 mL/g for the surface soils and 0.08 mL/g for the aquifer. These values are likely conservative because they maximize the leaching and transport of uranium in soil. No other contaminants are present above their respective groundwater-protection pathway CULs or soil indicator values at any deeper depths from this location.

3.7.1.2 Summary at 216-B-63 Trench

A summary of the 216-B-63 Trench COCs and COECs and their sample locations and depths with contaminant concentrations above their respective CULs is provided in Table 3-13b. As shown, soil boring E33-333 is the primary location with contaminant concentrations above groundwater-protection pathway CULs and ecological soil indicator values or BCGs.

However, boring E33-333 is not part of the 216-B-63 Trench and is included in Table 3-13b for information only. No remedial actions will be evaluated in this FS based on this sample location because it is located in a different OU. No risk drivers were identified at the 216-B-63 Trench.

Soil Boring B8827. Nine depth intervals were collected from this location, with depths ranging from 3 to 31.4 m (10 to 103 ft) bgs. Selenium (EF=1.4) was detected in a sample collected 3.2 to 4.0 m (10.5 to 13 ft) bgs but was not considered a risk driver for the reasons noted above. Cadmium (EF=2.4) was detected in the sample collected from 5.3 to 5.8 m (17.5 to 19 ft) bgs and was not considered a risk driver because its reported concentration is only slightly above the background value. No other contaminants are present above the groundwater-protection pathway CULs at any other depth from this location.

Test Pit BT-1. Five depth intervals were collected from this location, with depths ranging from 2.1 to 5.5 m (7 to 18 ft) bgs. Selenium (EF=1.3) was detected in a sample collected 2.1 to 2.4 m (7 to 8 ft) bgs but was not considered a risk driver for the reasons noted above. Methylene chloride (EF=1.2) is also not considered a risk driver, because the associated laboratory blank was contaminated with methylene chloride. No other contaminants are present above their respective groundwater-protection pathway CULs at any other depth from this location.

Test Pit BT-2. Eight depth intervals were collected from this location, with depths ranging from 1.5 to 7.6 m (5 to 25 ft) bgs. The sample collected from 1.5 to 1.8 m (5 to 6 ft) reported nitrate and benzene concentrations with EFs of less than 2. Because this waste site will require institutional controls and monitoring and nitrate is not considered an independent risk driver, benzene was not considered a risk driver. It is only slightly above its respective CUL and additional sampling and monitoring will better delineate the benzene concentration at this location. No other contaminants are present above their groundwater-protection pathway CULs at any other depth from this location. Thallium (EF=3.31), selenium (EF=2.5) and strontium-90 (EF=1.50 were identified as COECs. However, thallium and selenium were not considered risk drivers as discussed previously. The EFs for the Sr-90 are less than 1.5. It was not considered a risk driver due to low EFs and because additional sampling and long-term monitoring will accomplished to better delineate the extent of contamination at this location.

Soil Boring E33-333. Fifteen depth intervals were collected from this location, with depths ranging from 1.2 to 77.4 m (4 to 254 ft) bgs. Aroclor-1260 was detected in the samples collected from 2.4 to 3.2 m (8 to 10.5 ft) and 4 to 4.7 m (13 to 15.5 ft) at concentrations with calculated EFs ranging from 1.5 to 14. No other contaminants are present above the groundwater-protection pathway CULs at any other depth from this location. This borehole is not located in the trench itself and is located in a different OU near this waste site. High levels of Sr-90 resulted in a COEC with large EFs, but it was known that Sr-90 was spilled at this waste site before the effluent was redirected to the 216-B-63 Trench.

3.7.1.3 Summary at 216-S-10 Ditch

A summary of the COCs at the 216-S-10 Ditch, along with their sample locations, depths and EFs, is provided in Table 3-13c. As shown, Test Pit SD-2 is the primary location with COCs and risk drivers. The risk drivers associated with the groundwater-protection pathway include Aroclor-1254 and five PAHs. Additional COECs identified in the SLERA that are considered as risk drivers include total chromium and silver. Other COCs and COECs including mercury, copper, thallium, zinc and dibutyl phthalate are co-located with these risk drivers.

Test Pit SD-2. Only two depth intervals were collected from this location, with depths ranging from 0 to 0.9 m (0 to 3 ft) bgs. The sample collected from 0 to 0.5 m (1.5 ft) reported concentrations of six metals (including thallium), Aroclor-1254, five PAHs and dibutyl phthalate above their respective risk criteria. The sample collected from 0.5 to 0.9 m (1.5 to 3 ft) reported concentrations of total chromium and silver (see Figure 3-15). Note that no other samples were collected at deeper depths at this sample location. The COCs identified as risk drivers for the groundwater-protection pathway were Aroclor-1254 (EF=2.8) and PAHs (benzo(a)anthracene (EF=6.4), benzo(a)pyrene (EF=2.6), benzo(b)fluoranthene (EF=1.8), benzo(k)fluoranthene (EF=1.6), and chrysene (EF=7.1)). COECs identified as risk drivers were total chromium (EFs=12 and 4.3) and silver (EFs=7.2 and 6.8). Dibutyl phthalate was not considered an independent risk driver, however, it is co-located with several risk drivers at the location and depth.

Test Pit SD-3. Five depth intervals were collected from this location, with depths ranging from 0.9 to 4.3 m (3 to 14 ft) bgs. No contaminants are present above their groundwater-protection pathway CULs at any depth from this location. Thallium was found at 0.91 to 1.2 m (3 to 4 ft) bgs but is not considered a risk driver as described above in Section 3.7.

Soil Boring W26-14. Ten depth intervals were collected from this location, with depths ranging from 2 to 67.7 m (6.5 to 222 ft) bgs. Cadmium (EF=2.3) was detected in the sample collected from 7.6 to 8.2 m (25 to 27 ft) at a concentration slightly greater than background. This cadmium result is the higher of a sample pair. The other result from this sample location and depth was analyzed at a different laboratory and was below detection limits. No other contaminants are present above the groundwater-protection pathway CULs at any other depth from this location.

Test Pit SD-1. Five depth intervals were collected from this location, with depths ranging from 1.8 to 5.2 m (6 to 17 ft) bgs. Thallium (EF=4.3) and selenium (EF=1.5) were identified as COECs in the SLERA but as described above are not considered risk drivers.

3.7.1.4 Summary at 216-S-10 Pond

A summary of the COCs at the 216-S-10 Pond, along with their sample locations, depths, and EFs, is provided in Table 3-13d. No risk drivers were identified at the 216-S-10 Pond..

Test Pit SP-1. Seven depth intervals were collected from this location, with depths ranging from 2.1 to 7.6 m (7 to 25 ft) bgs. No contaminants are present above their groundwater-protection pathway CULs at any depth from this location. No COECs were identified in the SLERA.

Test Pit SP-2. Seven depth intervals were collected from this location, with depths ranging from 2.0 to 7.9 m (6.5 to 26 ft) bgs. Carbon-14 (EF=4.1) was detected in the sample collected from 2 to 2.3 m (6.5 to 7.5 ft) that resulted in an estimated groundwater concentration greater than the drinking water maximum contaminant level. Note that carbon-14 was only detected at this location and not at any other location. Carbon-14 was identified by RESRAD as a COC. However, only one of the four samples had a detected result. The maximum predicted groundwater concentration for the 216-S-10 Pond was 8,260 pCi/L which exceeded the C-14 maximum contaminant level of 2,000 pCi/L. Assuming linearity between the maximum groundwater concentration and the soil concentration in RESRAD (a valid assumption inherent in RESRAD), the estimated C-14 soil concentration that would result in meeting the maximum contaminant level is:

Carbon-14 in soil = maximum detected concentration/exceedances factor=12.2 pCi/g / 4.1 = 2.95 pCi/g.

However, the EPA preliminary remediation goal for C-14 for the soil to groundwater route is 40 pCi/g with a dilution factor of 20. This same dilution factor is assumed in the nonradionuclide WAC three-phase model. The preliminary remediation goal of 40 pCi/g is greater than the one detected value of 12.2 pCi/g. Because only one sample from the four sample locations across the waste site had a positive detection and that single sample was used to estimate the C-14 inventory across the entire waste site, and the EPA preliminary remediation goal for C-14 is greater than the one detected result, C-14 does not warrant designation as a risk driver. However, additional sampling should be performed to confirm and better delineate C-14 in the 216-S-10 Pond.

No contaminants are present above their groundwater-protection pathway CULs at any depth from this location. Silver was identified as a COEC in the SLERA, but was not considered a risk driver as described above in Section 3.7.

Test Pit SP-3. Seven depth intervals were collected from this location, with depths ranging from 2.1 to 7.6 m (7 to 25 ft) bgs. Methylene chloride (EF=1.1) was detected in the sample collected from 4.9 to 5.2 m (16 to 17 ft) at a concentration only slightly above the CUL and is not considered a COC. No other contaminants are present above their groundwater-protection pathway CULs at any other depth from this location. No COECs were identified at this location.

Test Pit SP-4. Seven depth intervals were collected from this location, with depths ranging from 1.2 to 7.6 m (4 to 25 ft) bgs. No contaminants are present above their groundwater-protection pathway CULs at any depth from this location. Only thallium and selenium were identified as COECs but are not considered risk drivers as discussed above in Section 3.7.

Soil Boring W26-13. Eight depth intervals were collected from this location, with depths ranging from 10 to 60.7 m (33 to 199 ft) bgs. No contaminants are present above their groundwater-protection pathway CULs at any depth from this location. No COECs were identified in the SLERA at this location.

3.7.2 Uncertainty in Risk Determinations

The purpose of the BRA is to identify and characterize potential risks and hazards to human health and the environment. These findings are used in the FS to select appropriate remedies to reduce risks to target cleanup goals established by the EPA and State of Washington. Estimating and evaluating risks from exposure to environmental contaminants is a complex process with inherent uncertainties. Uncertainty reflects limitations in knowledge and simplifying assumptions that must be made to quantify risks. Underestimation or overestimation of risk can lead, respectively, to failure to remediate true hazards or unnecessary cleanup and expense.

The following uncertainty discussion concludes that the sampling strategy employed in the RI, coupled with strict adherence to CERCLA and *Washington Administrative Code* guidance, results in risk determinations that are more likely overestimated than underestimated. In addition, it is important to note that the biased sampling targeted worst-case/maximum concentrations at the expense of fully characterizing each site. As a result, the risk assessment is based on biased and limited data, and the approach followed purposefully avoids false-negative risk conclusions. The limitations with the characterization data were not considered severe, because it is anticipated that additional sampling will be incorporated in the remedial design/remedial action process to better characterize the site and to address the more likely false-positive errors.

In general, uncertainty in the results of the analysis described above can be classified into four types (*Confronting Uncertainty in Risk Management: A Guide for Decision Makers* [Finkel, 1990]; "Assessment of Variability and Uncertainty Distributions for Practical Risk Analyses" [Hattis and Burmaster, 1994]):

- Parameter uncertainty
- Model uncertainty
- Decision-rule uncertainty
- Variability.

Of these, the first two often provide much of the overall uncertainty in risk assessment (in contrast to risk management) and are the main source of uncertainty for this BRA, as described above in Sections 3.4, 3.5, and 3.6.

Parameter Uncertainty. This includes both measurement errors and random and/or systematic errors arising from the inability to measure variables precisely and accurately (equipment and laboratory protocol problems) or because the quantity being measured varies spatially or temporally. For these risk assessments, basic methodological (laboratory processing and equipment) errors were evaluated in the DQO process, and the data sets were determined to be suitable to support qualitative risk assessment.

Most important, the sampling strategy employed at the sites in this operable unit was biased to identify worst case contaminant conditions at each site. Consequently, geostatistical approaches to characterize the spatial distributions of contaminants cannot be applied, and the ability to quantify variability and uncertainty from the sampling data is limited. The maximum concentrations of the biased sampling results were used to represent the entire ditch, trench, or pond, and likely overestimate the exposure-point concentrations and lead to false-positive risk results. There were, however, large areas that were not sampled and samples that were not analyzed for the full suite of contaminants. These omissions were professional judgments exercised in the RI. As a result, there may be uncertainties regarding the representativeness of the samples in characterizing the exposure area. These uncertainties may cause hesitation in trusting that the biased results also bias the assessment toward an overestimate of risk. However, the backfill currently covering all waste sites, except the 216-S-10 Ditch, likely prevents exposure to employees working on top of the waste sites and ecological receptors.

Model Uncertainty. Model-associated uncertainties can arise from the use of surrogate variables, excluded variables that should have been included, abnormal conditions not anticipated in the model, incorrect model forms, and parameter specification. RESRAD modeling was used to assess radionuclide exposures and potential groundwater impacts. As discussed above, the conservative bias that is included in the RESRAD analysis of these sites likely resulted in an overestimate of contaminant concentrations in groundwater and human health impacts. The WAC three-phase model was used for the groundwater-protection pathway analysis. However, it does not account for site-specific information. For example, the depth to the aquifer is not included in the three-phase model. General parameters as opposed to site-specific parameters can lead to either overestimation or underestimation of contaminants in groundwater.

Decision-Rule Uncertainty. Unlike the first two elements, decision-rule uncertainty is more important to the risk manager rather than to the risk assessor. Examples include uncertainties within the process of evaluating competing or different priorities among socioeconomic, policy or guidance concerns when arriving at an acceptable level of measured or modeled risk. For this document, understanding the conservative treatment of uncertainty in the risk analyses (i.e., bias toward avoiding false-negative risk conclusions) and how that affects alternative evaluations in the FS, is critical to making sound risk-management decisions when considering remedy development and costs and applying balancing criteria in the remedial design/remedial action phase.

Variability. Variability often can be confused with uncertainty, but it is important to understand the difference in the context of the problem being addressed. Variability describes the underlying and relatively stable distribution of some parameter that can be empirically characterized in knowable biological, physical, biophysicochemical, or chemical terms. Variability can be characterized empirically in an exposure population, but that does not eliminate its contribution to overall uncertainty.

Characterizing Uncertainty. Uncertainty can be assessed formally through quantitative analyses, or it can be described qualitatively. The choice of qualitative or quantitative approaches depends on the completeness of the database and the original strategy and intended purpose. In formal quantitative analysis, the variability and uncertainty with each parameter in the risk-estimation process is first quantified. Uncertainty is described by inclusion of a standard error of means or probability density functions (relative probability for discrete parameter values). Numerical methods then can be used to develop a composite uncertainty distribution by merging all individual distributions. For the data sets used in this risk assessment, because "variability" cannot be systematically and quantitatively assessed, uncertainty only can be addressed qualitatively.

Error in Uncertainty Analyses. This risk assessment produces the potential for two kinds of errors. The first potential error (Type I) is the identification of a specific contaminant, area, or activity as a health concern when, in fact, it is not a concern (false-positive conclusion). The second potential (Type II) is the elimination of a chemical, area, or activity from further consideration when, in fact, there should be a concern (false-negative conclusion). In this BRA, uncertainties were handled conservatively (i.e., choices protective of health and the environment were made preferentially). This strategy is more likely to produce false-positive errors than false-negative errors. False-positive errors can lead to over-specification of the remedy. This result was envisioned in the DQO assessment, and it is anticipated that this uncertainty will be addressed in post-ROD, remedial design/remedial action confirmatory sampling.

3.7.3 Implications for the Feasibility Study

The summary and uncertainty discussion presented above is important so that risk managers understand the underlying assumptions, characterization data, and derivation of the risk drivers for the alternative evaluations completed in the FS. Tables 3-13a through 3-13d summarize the soil COCs with sufficient toxicological information to estimate ecological risks and potential groundwater impacts. Although a number of COCs were identified, not all would be considered risk drivers, as described in the above sections. As outlined in the Work Plan (DOE/RL-99-44), additional sampling will better delineate COCs and COECs at these waste sites, and those results may have impacts on the remedial evaluations made in this FS and the remedial determinations made in the Proposed Plan. Table 3-14 and the following text summarize those COCs and COECs considered risk drivers by waste site and depth.

216-A-29 Ditch. Risk drivers to be considered for remedial actions in the FS were identified at the following sample locations and depths:

- Test Pit AD-1, 1.2 to 1.5 m (4 to 5 ft): Aroclor-1254, silver, Cs-137, bis (2-ehtylhexyl) phthalate, cadmium, 1,2-dichloroethane, PAHs (benzo(a)anthracene and chrysene), and tetrachloroethylene
- Soil Boring B8826, 1.2 to 2 m (4 to 6.5 ft): Aroclor-1254, cadmium, and tributyl phosphate.

Additional sampling is recommended towards the outlet end of this Ditch to better delineate the uranium and other metals concentrations observed around 2.3 to 2.6 m (7.5 to 8.5 ft).

216-B-63 Trench. No risk drivers were identified for remedial actions in this waste site. Borehole E33-333 results in some exceedances, but is located in another OU and will not be evaluated in this FS. Radionuclide dose exceedances were identified at this waste site if the existing cover were to be removed. The results of this analysis estimated total annual doses greater than 15 mrem/y within 150 years, but the dose criterion was met after 150 years. Therefore, the cover at this waste site needs to be maintained for at least 150 years to prevent potential exposure. Additional sampling is recommended to better delineate the benzene and strontium-90 concentrations detected at the outlet of this Trench.

216-S-10 Ditch. Risk drivers to be considered for remedial actions in the FS were identified at the following sample locations and depths:

- <u>Test Pit SD-2</u>, 0 to 0.9 m (3 ft): silver, Aroclor-1254, and the PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene].

Additional sampling is recommended to better delineate the vertical extent of contamination at this location because no sample results currently exist below 0.9 m (3 ft).

216-S-10 Pond. No risk drivers were identified for remedial actions in this waste site. Radionuclide doses greater than 15 mrem/y were not identified at this waste site if the existing cover were to be removed. This applies to the analogous 216-S-11 Pond waste site. Additional sampling is recommended at this waste site to confirm or better delineate the one C-14 detected result observed in the middle of the Pond.

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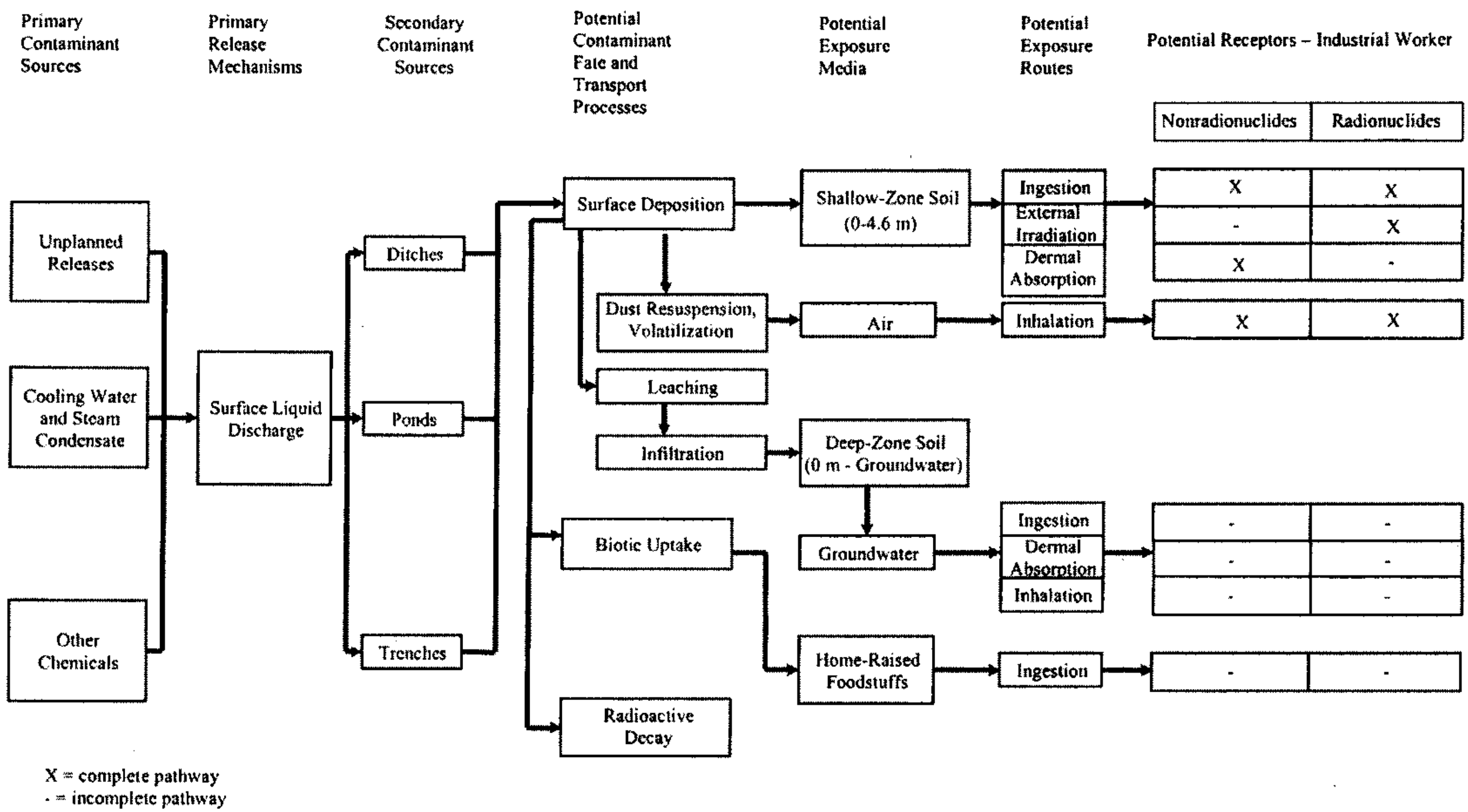


Figure 3-1. Conceptual Model for Human Health.

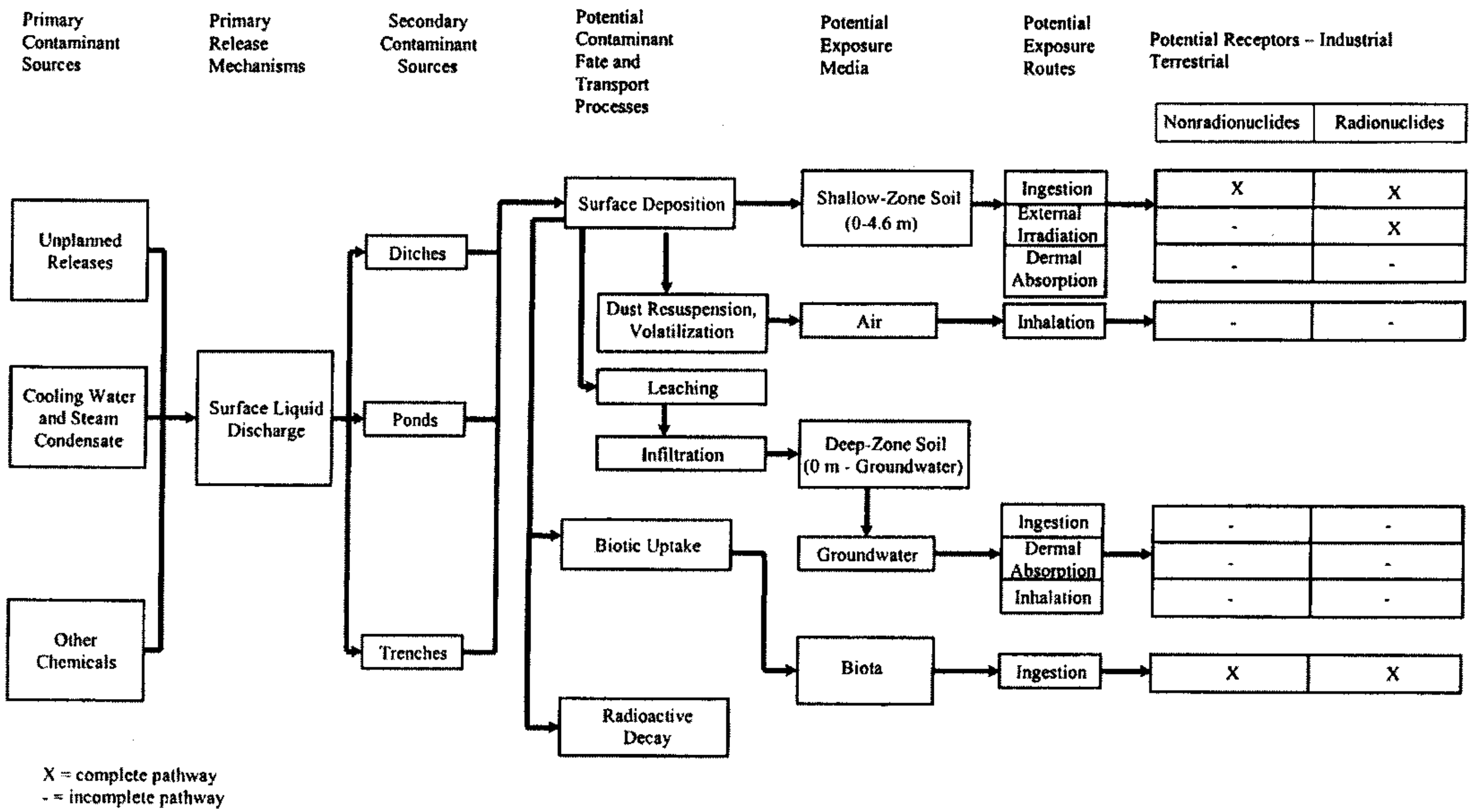


Figure 3-2. Conceptual Model for Ecological Receptors (Industrial Land-use).

Figure 3-3. Initial Data Evaluation Steps.

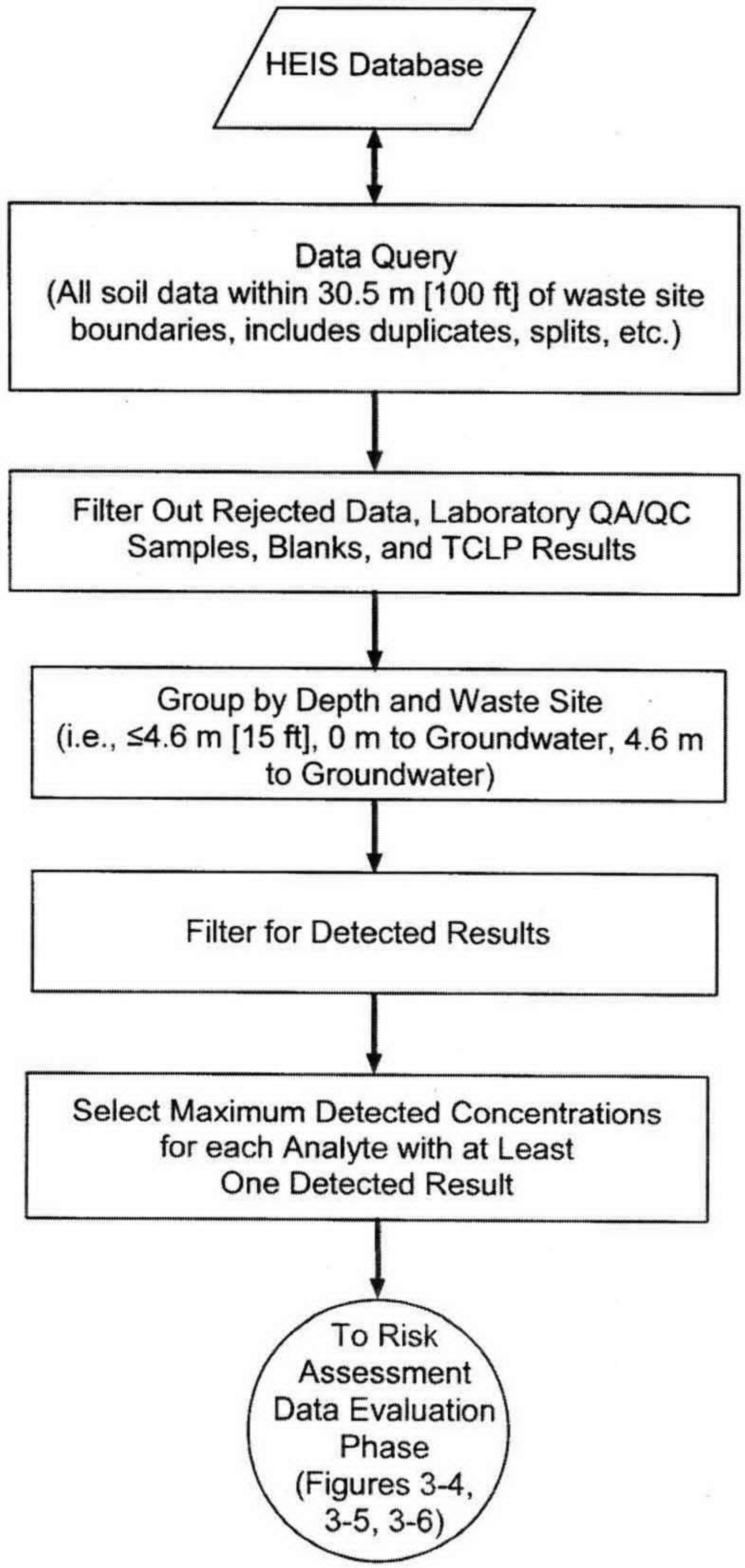
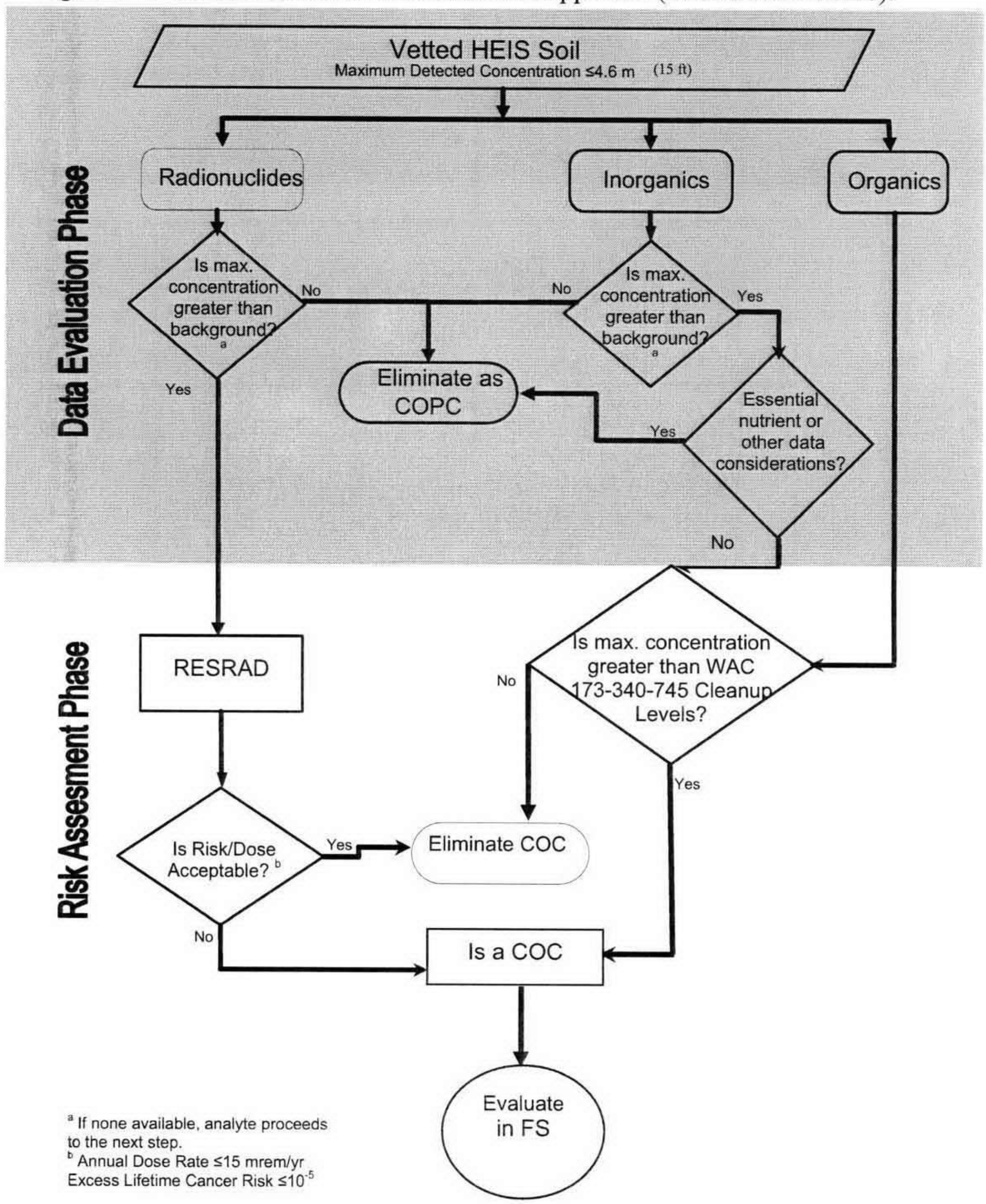
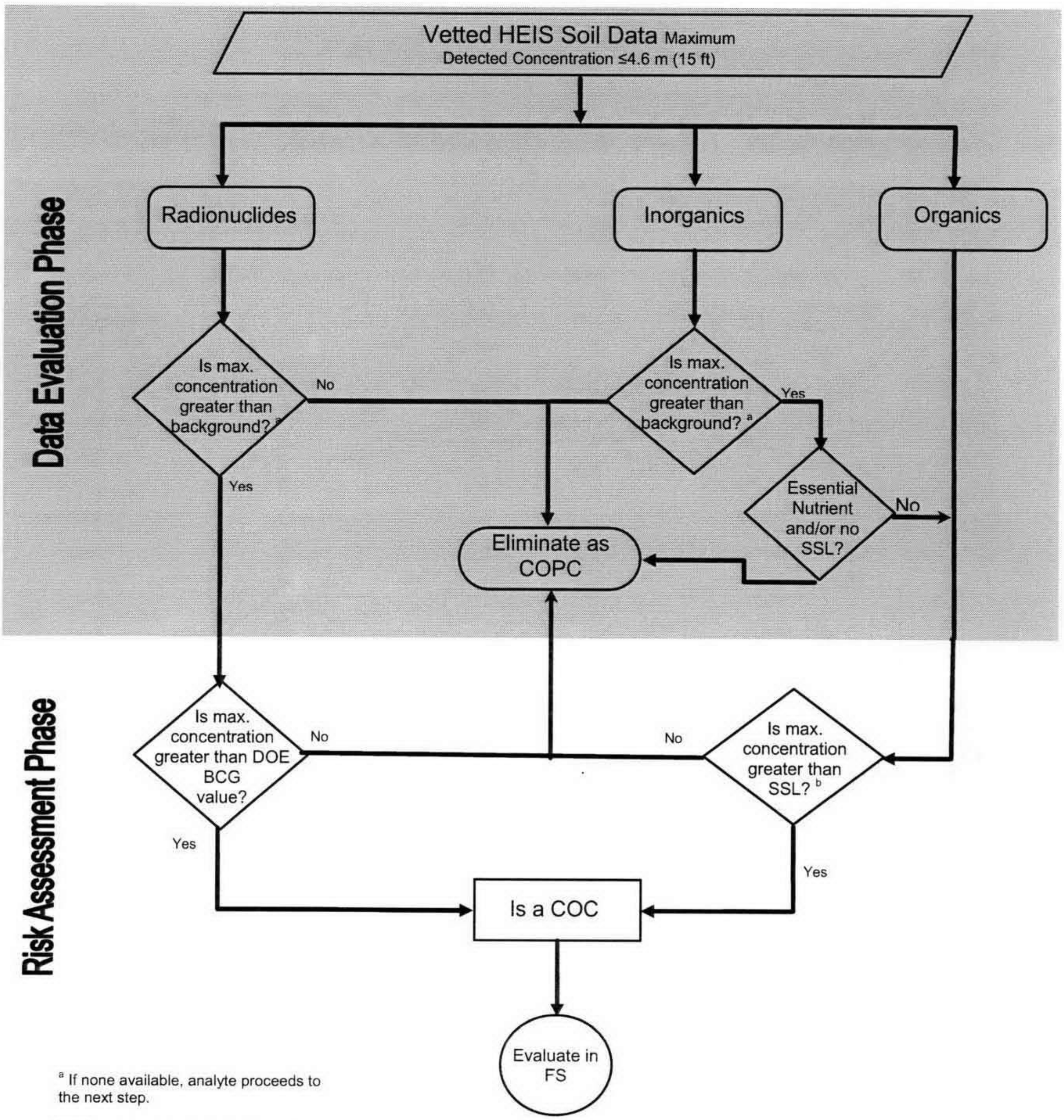


Figure 3-4. Human Health Risk Assessment Approach (Industrial Scenario).



COPC = Contaminant of potential concern
COC = Contaminant of concern
WAC = Washington Administration Code
FS = feasibility study
HEIS = Hanford Environmental Information System

Figure 3-5. Ecological Risk Assessment Approach (Industrial Scenario).

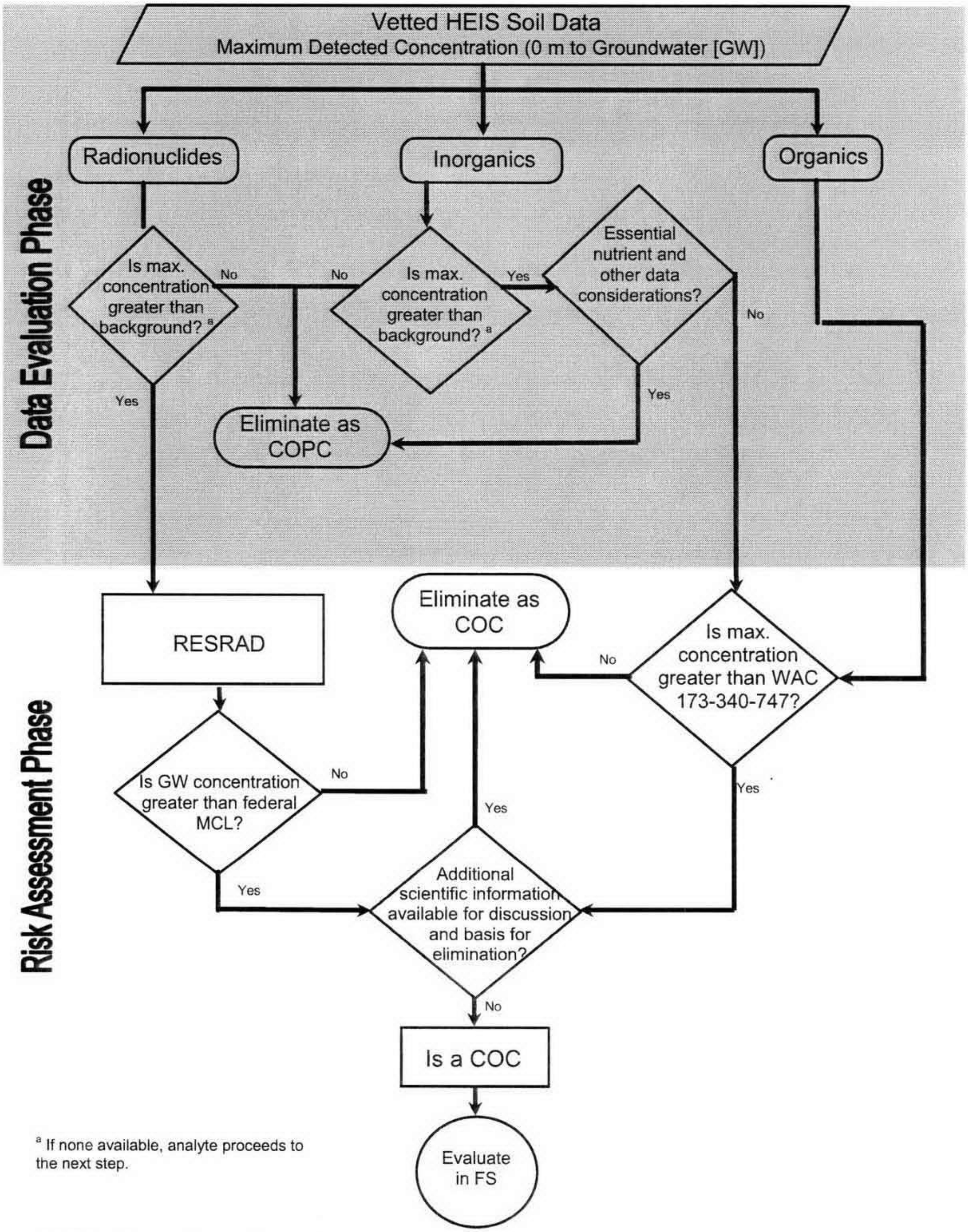


[a] If none available, analyte proceeds to the next step.

[b] SSLs selected in the following order:
WAC 173-340-900
Eco-SSL
ORNL

COPC = Contaminant of potential concern
COC = Contaminant of concern
WAC = Washington Administration Code
FS = feasibility study
HEIS = Hanford Environmental Information System
BCG = Biota Concentration Guideline
SSL = soil screening level
ORNL = Oak Ridge National Laboratory

Figure 3-6. Groundwater Protection Pathway Approach.



[a] If none available, analyte proceeds to the next step.

COPC = Contaminant of potential concern
COC = Contaminant of concern
WAC = Washington Administration Code
FS = feasibility study
HEIS = Hanford Environmental Information System
RESRAD = Residual Radioactivity code
GW = groundwater

Figure 3-7. Tritium Concentrations in Groundwater from Head of 216-A-29 Ditch.

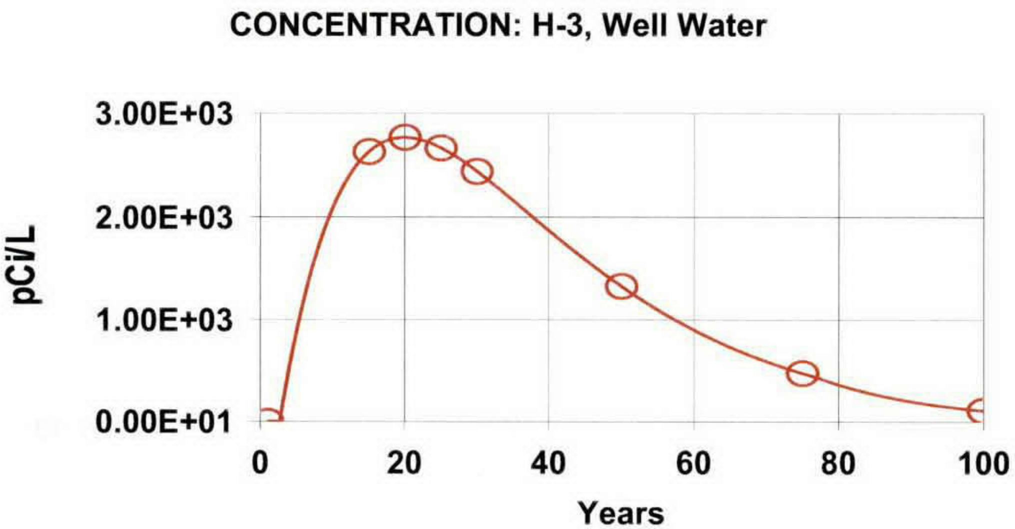


Figure 3-8. Uranium-234 Concentrations in Groundwater from Outlet of 216-A-29 Ditch.

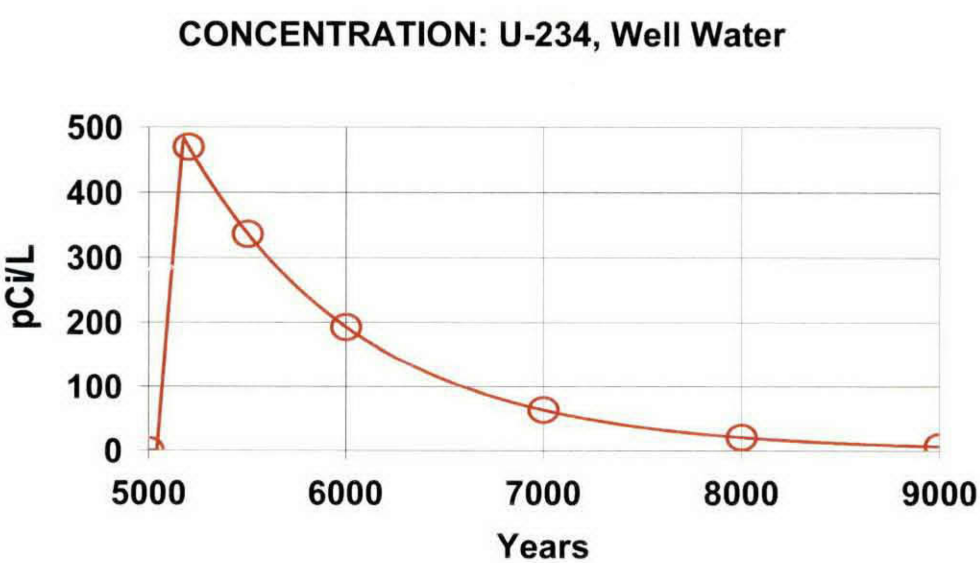


Figure 3-9. Uranium-238 Concentrations in Groundwater from Outlet of 216-A-29 Ditch.

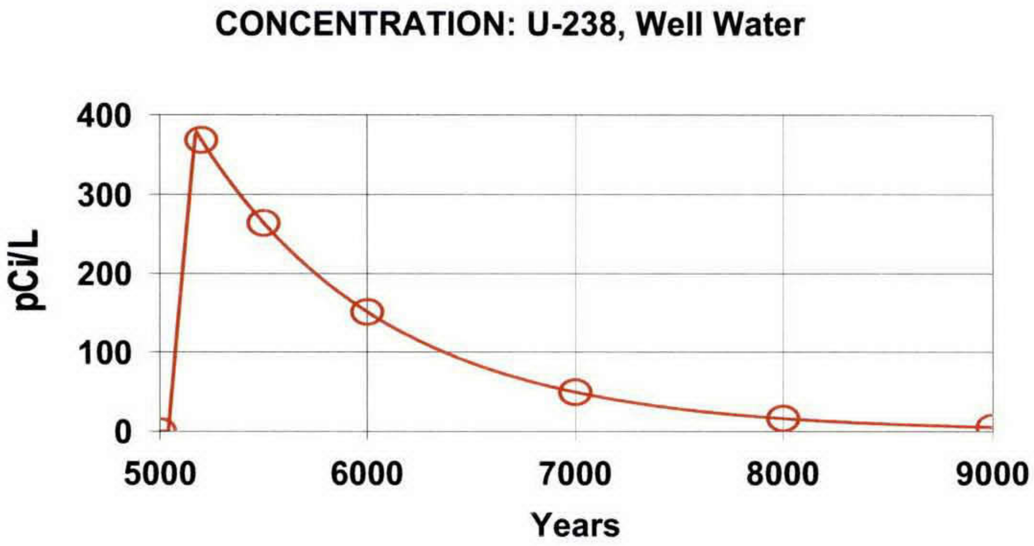


Figure 3-10. Technitium-99 Concentrations in Groundwater from 216-B-63 Trench.

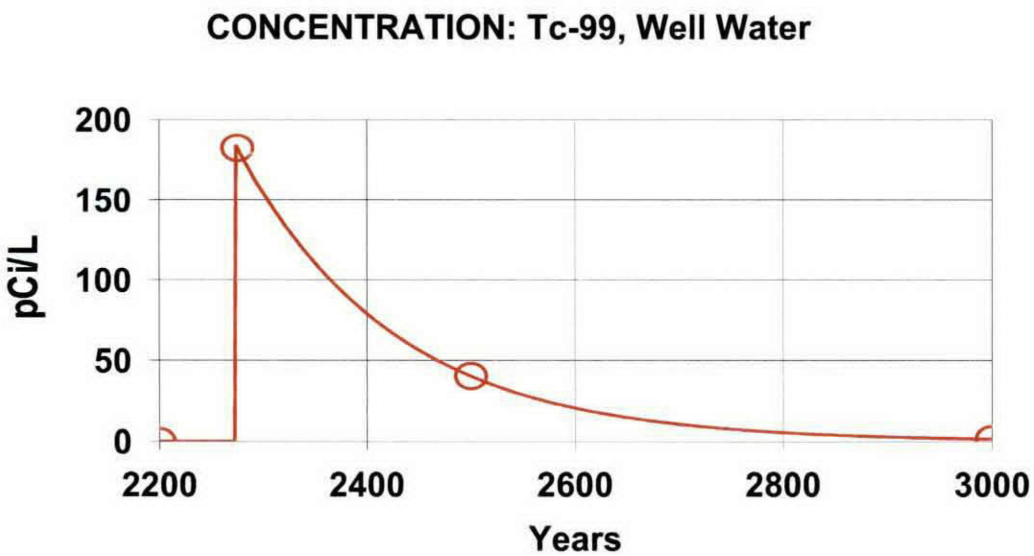


Figure 3-11. Carbon-14 Concentrations in Groundwater from 216-S-10 Pond.

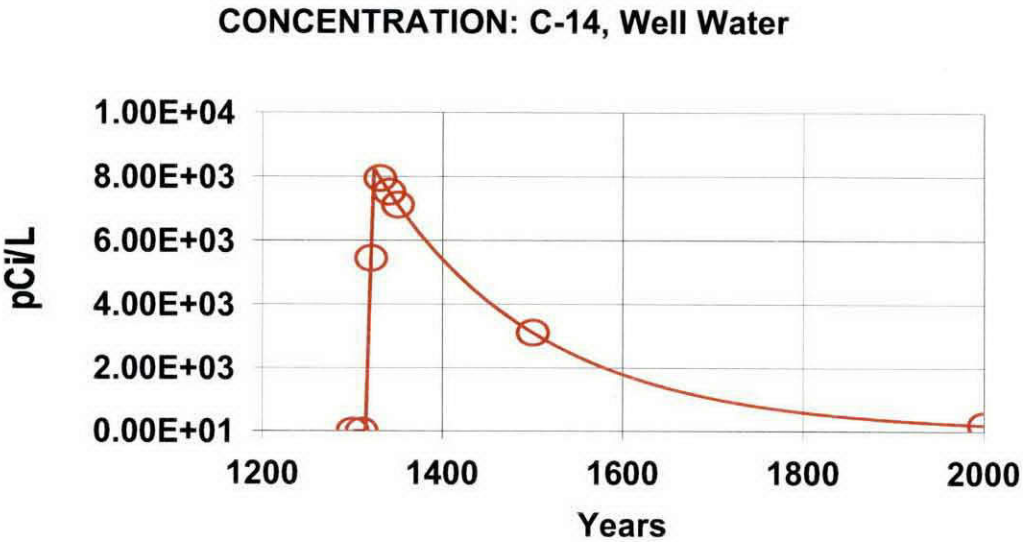


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Figure 3-12. Selenium Concentrations by Waste Site.

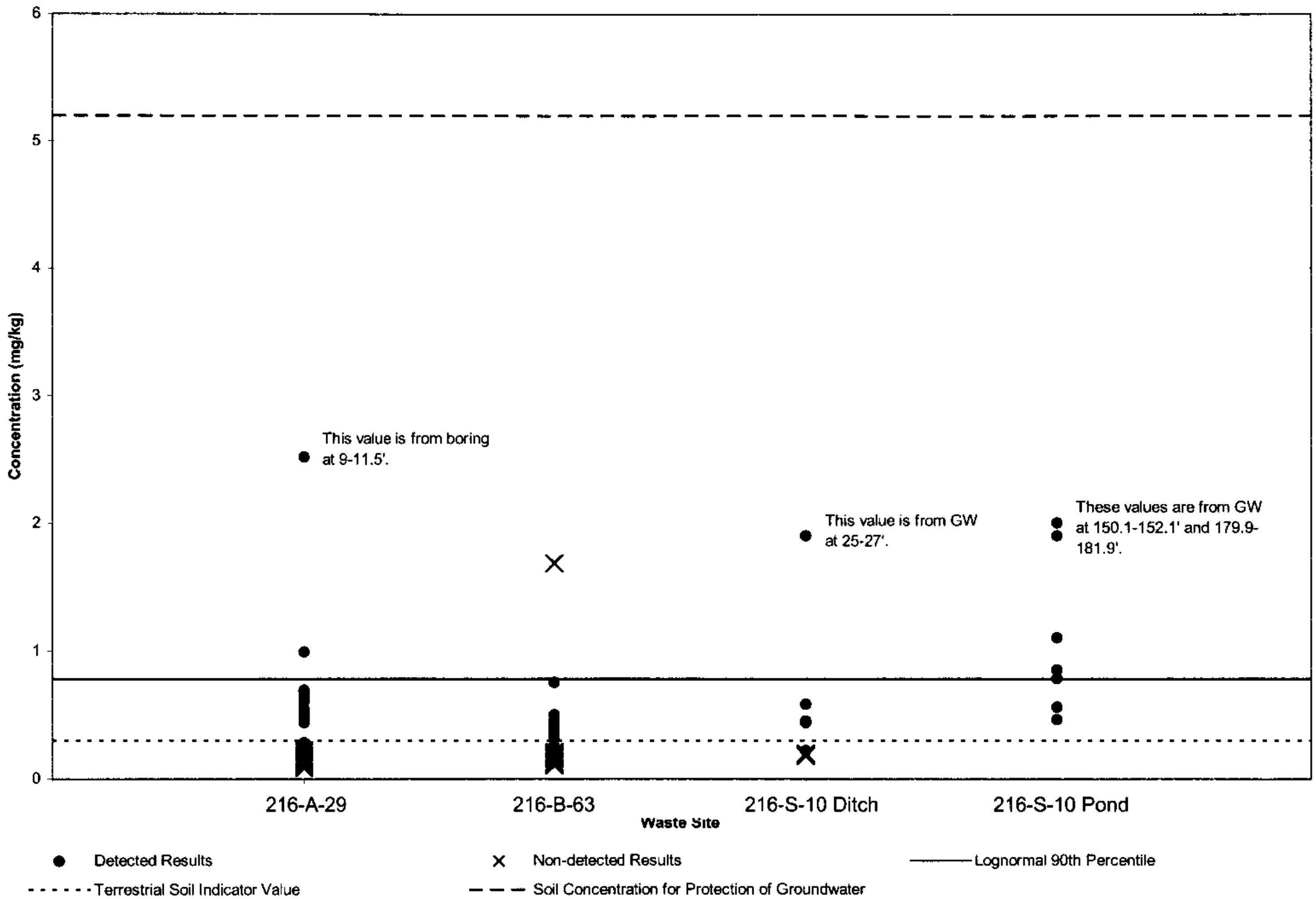

Figure 3-13. Thallium Concentrations by Waste Site.

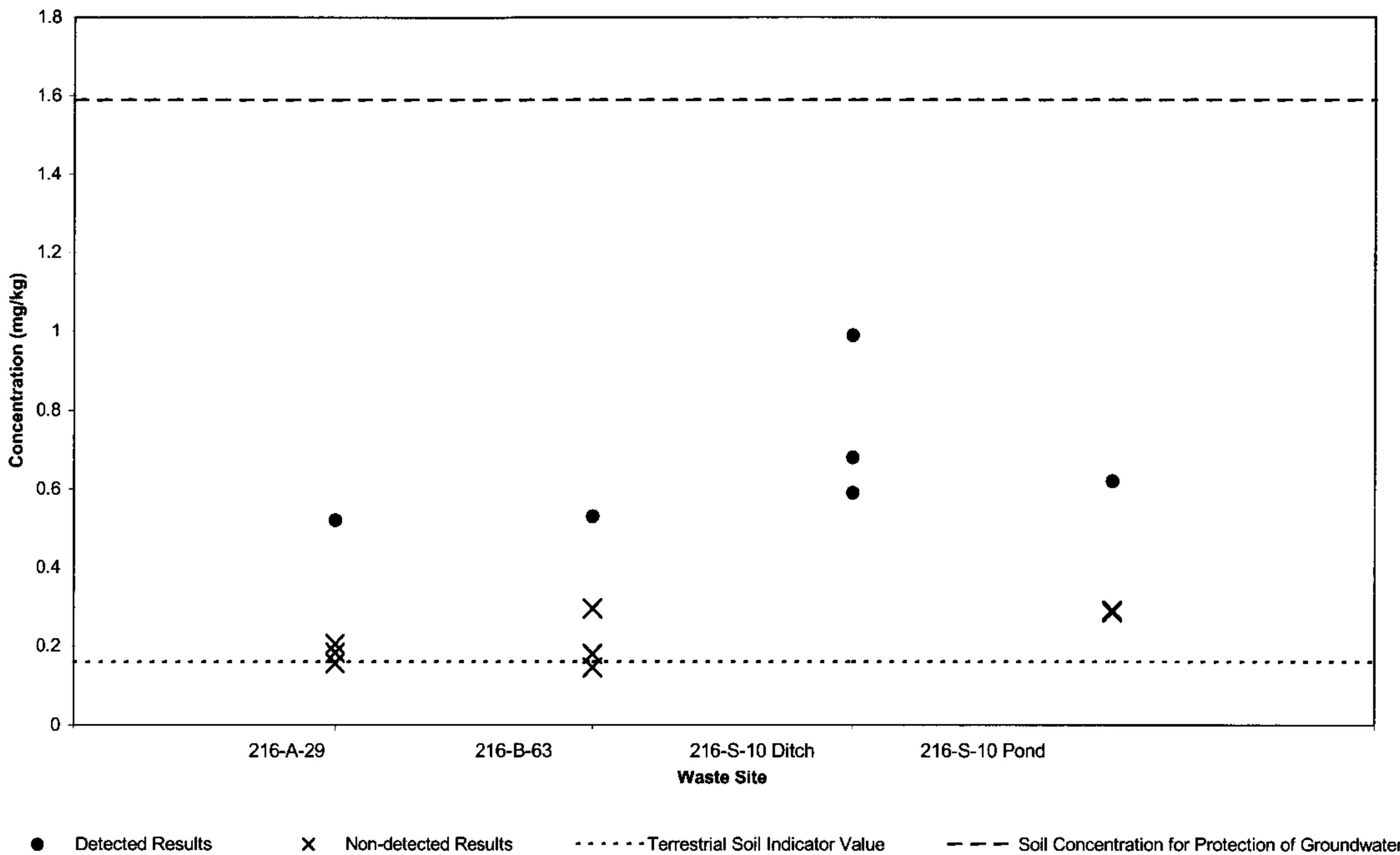

Figure 3-14. Cadmium Concentrations by Waste Site.

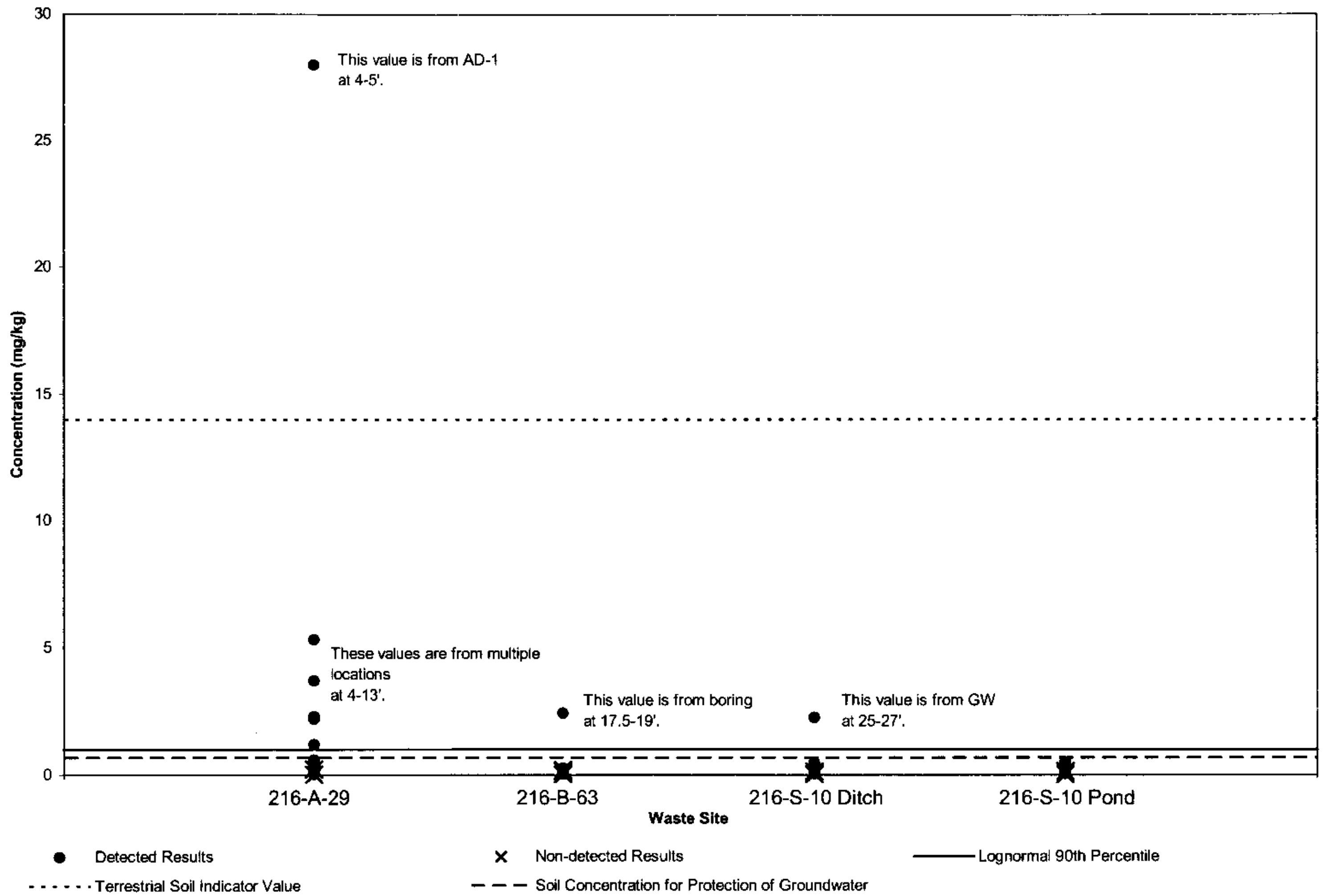

Figure 3-15. Silver Concentrations by Waste Site.

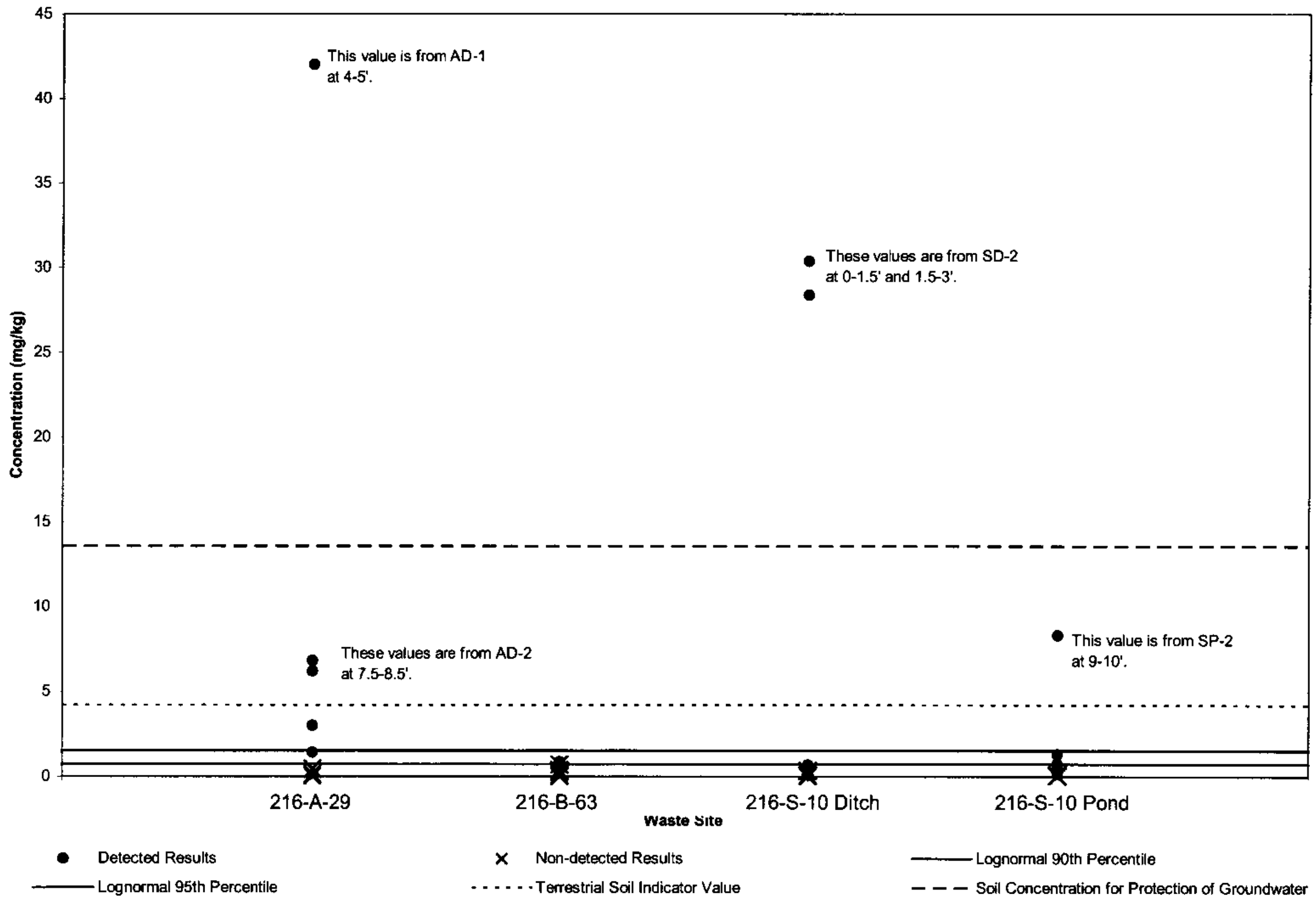

Figure 3-16. Arsenic Concentrations by Waste Site.

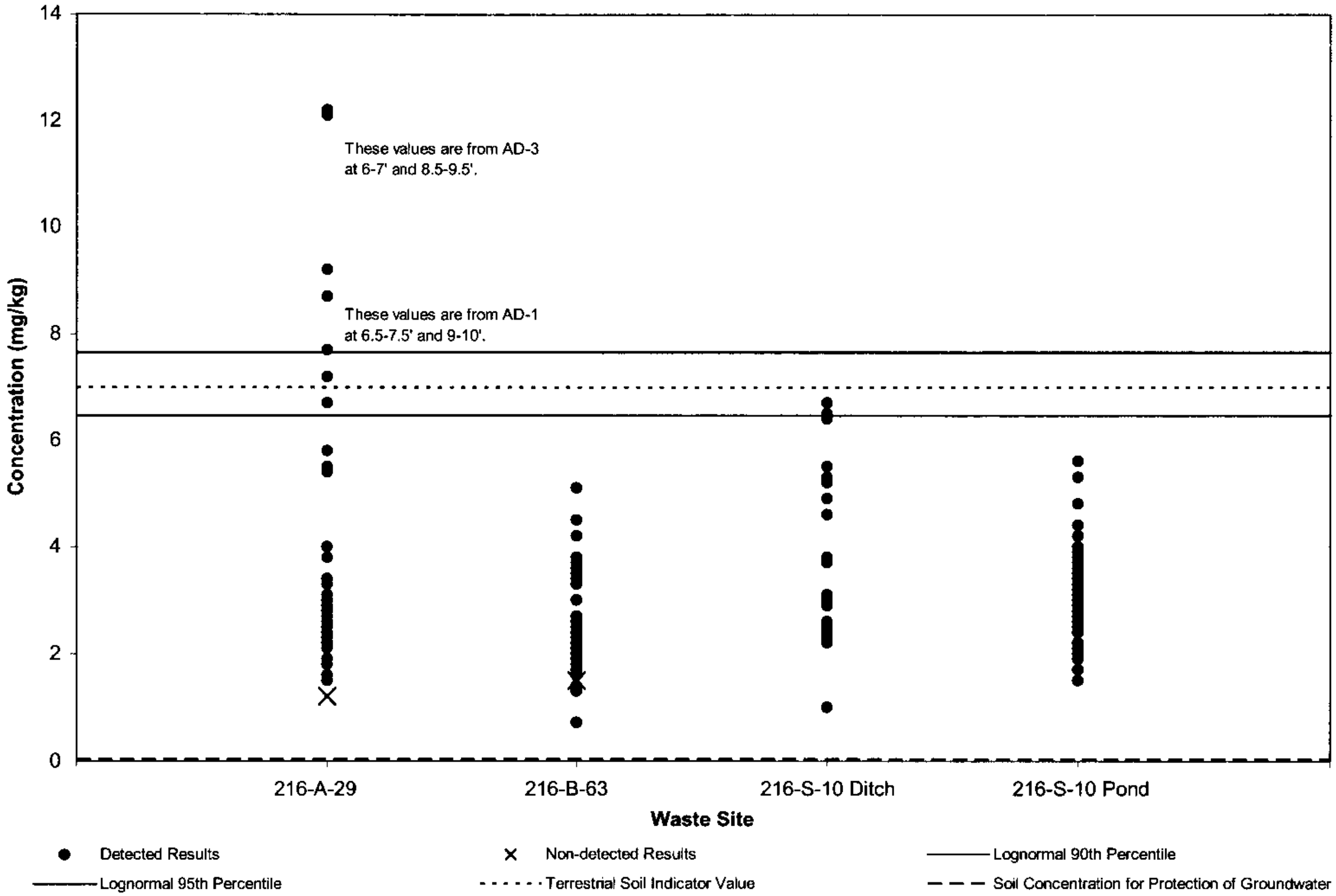

Figure 3-17. Chromium (Total) Concentrations by Waste Site.

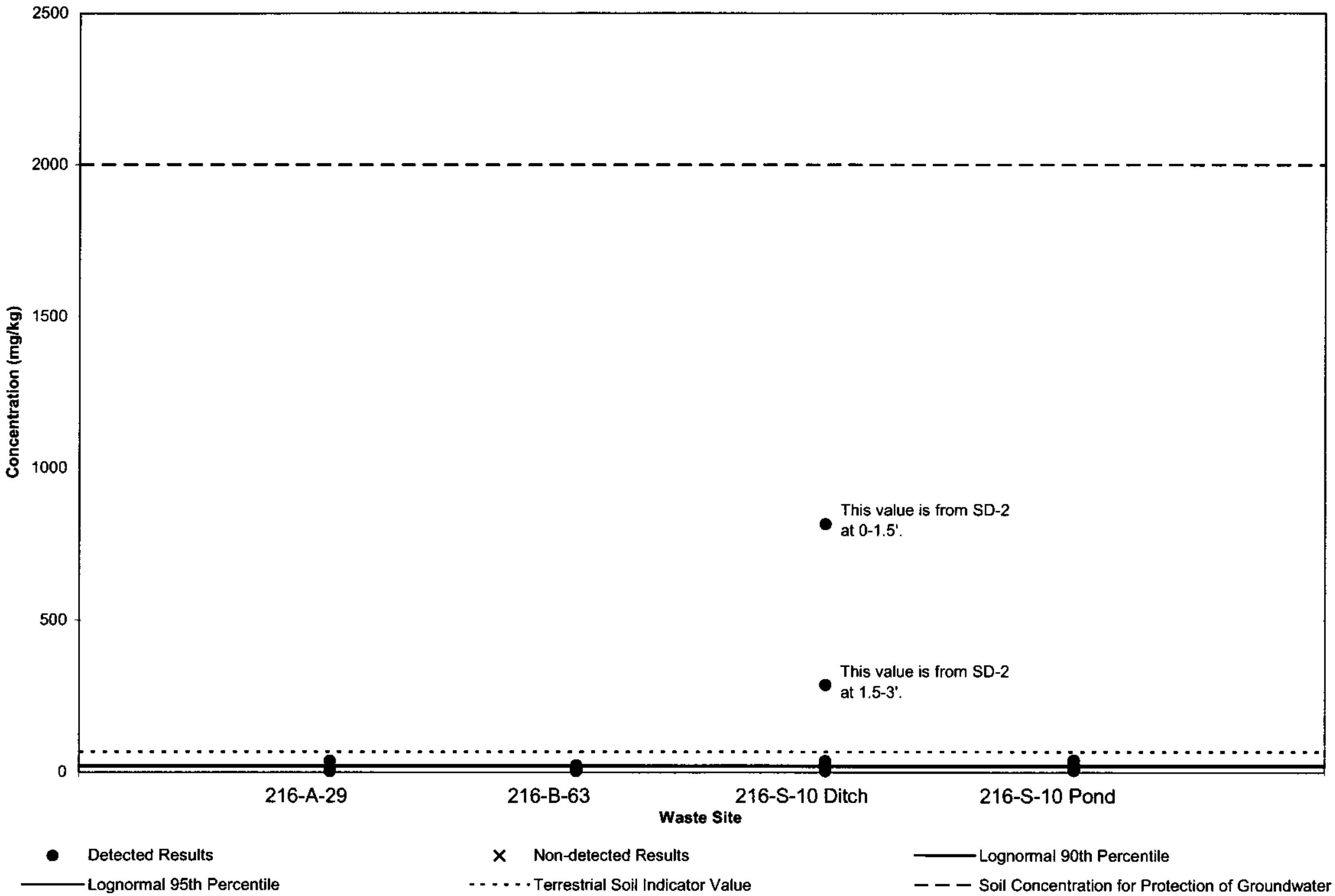

Table 3-1. Hanford Site-specific Background Concentrations. (3 sheets)

Class	Constituent	Units	Lognormal 90th Percentile Value	90% UCL	Lognormal 95th Percentile Value	Source of Background Values
METAL	Aluminum (7429-90-5)	mg/kg	11800	13000	13300	DOE/RL-92-24, V.1, Rev.4
METAL	Arsenic (7440-38-2)	mg/kg	6.47	7.38	7.65	DOE/RL-92-24, V.1, Rev.4
METAL	Barium (7440-39-3)	mg/kg	132	144	148	DOE/RL-92-24, V.1, Rev.4
METAL	Beryllium (7440-41-7)	mg/kg	1.51	1.62	1.65	DOE/RL-92-24, V.1, Rev.4
METAL	Cadmium (7440-43-9)	mg/kg	1	~	~	Statewide Conc.; WA Pub. #94-115; Oct. 2004
METAL	Calcium (7440-70-2)	mg/kg	17200	19700	20400	DOE/RL-92-24, V.1, Rev.4
METAL	Chromium (7440-47-3)	mg/kg	18.5	21.4	22.3	DOE/RL-92-24, V.1, Rev.4
METAL	Cobalt (7440-48-4)	mg/kg	15.7	16.9	17.3	DOE/RL-92-24, V.1, Rev.4
METAL	Copper (7440-50-8)	mg/kg	22	24.1	24.7	DOE/RL-92-24, V.1, Rev.4
METAL	Iron (7439-89-6)	mg/kg	32600	35000	35600	DOE/RL-92-24, V.1, Rev.4
METAL	Lead (7439-92-1)	mg/kg	10.2	11.7	12.2	DOE/RL-92-24, V.1, Rev.4
METAL	Magnesium (7439-95-4)	mg/kg	7060	7620	7780	DOE/RL-92-24, V.1, Rev.4
METAL	Manganese (7439-96-5)	mg/kg	512	550	561	DOE/RL-92-24, V.1, Rev.4
METAL	Mercury (7439-97-6)	mg/kg	0.33	0.6	0.7	DOE/RL-92-24, V.1, Rev.4
METAL	Molybdenum	mg/kg	2.8-6.0 (a)	~	~	Judgmental samples, DOE/RL-92-24
METAL	Nickel (7440-02-0)	mg/kg	19.1	21	21.6	DOE/RL-92-24, V.1, Rev.4
METAL	Potassium (7440-09-7)	mg/kg	2150	2440	2520	DOE/RL-92-24, V.1, Rev.4
METAL	Silver (7440-22-4)	mg/kg	0.73	1.33	1.52	DOE/RL-92-24, V.1, Rev.4
METAL	Sodium (7440-23-5)	mg/kg	690	878	937	DOE/RL-92-24, V.1, Rev.4
METAL	Uranium (7440-61-1)	mg/kg	3.21	~	~	Isotopic Activity Conversion based on DOE/RL-96-12 values
METAL	Vanadium (7440-62-2)	mg/kg	85.1	93.9	96.4	DOE/RL-92-24, V.1, Rev.4

Table 3-1. Hanford Site-specific Background Concentrations. (3 sheets)

Class	Constituent	Units	Lognormal 90th Percentile Value	90% UCL	Lognormal 95th Percentile Value	Source of Background Values
METAL	Zinc (7440-66-6)	mg/kg	67.8	72.1	73.3	DOE/RL-92-24, V.1, Rev.4
RAD	Cesium-137 (10045-97-3)	pCi/g	1.05	~	1.51	DOE/RL-96-12, Rev.0
RAD	Cobalt-60 (10198-40-0)	pCi/g	8.42E-03	~	0.0104	DOE/RL-96-12, Rev.0
RAD	Europium-154 (15585-10-1)	pCi/g	3.34E-02	~	4.27E-02	DOE/RL-96-12, Rev.0
RAD	Europium-155 (14391-16-3)	pCi/g	5.39E-02	~	7.23E-02	DOE/RL-96-12, Rev.0
RAD	Gross beta (12587-47-2)	pCi/g	22.96	~	24.07	DOE/RL-96-12, Rev.0
RAD	Plutonium-238 (13981-16-3)	pCi/g	0.00378	~	6.48E-03	DOE/RL-96-12, Rev.0
RAD	Plutonium-239/240 (PU-239/240)	pCi/g	2.48E-02	~	3.66E-02	DOE/RL-96-12, Rev.0
RAD	Potassium-40 (13966-00-2)	pCi/g	16.6	~	17.9	DOE/RL-96-12, Rev.0
RAD	Radium-226 (13982-63-3)*	pCi/g	0.815	~	0.928	DOE/RL-96-12, Rev.0
RAD	Radium-228 (15262-20-1)*	pCi/g	1.32	~	1.47	DOE/RL-96-12, Rev.0
RAD	Strontium-90 (10098-97-2)	pCi/g	0.178	~	0.247	DOE/RL-96-12, Rev.0
RAD	Thorium-228 (14274-82-9)*	pCi/g	1.32	~	1.47	DOE/RL-96-12, Rev.0
RAD	Thorium-230 (14269-63-7)*	pCi/g	1.1	~	1.23	DOE/RL-96-12, Rev.0
RAD	Thorium-232 (TH-232)	pCi/g	1.32	~	1.47	DOE/RL-96-12, Rev.0
RAD	Total beta radiostrontium (SR-RAD)	pCi/g	0.178	~	0.247	DOE/RL-96-12, Rev.0
RAD	Uranium-233/234 (U-233/234)*	pCi/g	1.1	~	1.23	DOE/RL-96-12, Rev.0
RAD	Uranium-234 (13966-29-5)*	pCi/g	1.1	~	1.23	DOE/RL-96-12, Rev.0
RAD	Uranium-235 (15117-96-1)	pCi/g	0.109	~	0.153	DOE/RL-96-12, Rev.0
RAD	Uranium-238 (U-238)	pCi/g	1.06	~	1.18	DOE/RL-96-12, Rev.0
WETCHEM	Ammonia (7664-41-7)	mg/kg	9.23	15.1	17.3	DOE/RL-92-24, V.1, Rev.4
WETCHEM	Chloride (16887-00-6)	mg/kg	100	182	214	DOE/RL-92-24, V.1, Rev.4
WETCHEM	Fluoride (16984-48-8)	mg/kg	2.81	3.7	3.98	DOE/RL-92-24, V.1, Rev.4

Table 3-1. Hanford Site-specific Background Concentrations. (3 sheets)

Class	Constituent	Units	Lognormal 90th Percentile Value	90% UCL	Lognormal 95th Percentile Value	Source of Background Values
WETCHEM	Nitrate (14797-55-8)	mg/kg	52	93.4	110	DOE/RL-92-24, V.1, Rev.4
WETCHEM	Phosphate (14265-44-2)	mg/kg	0.785	2.87	4.08	DOE/RL-92-24, V.1, Rev.4
WETCHEM	Sulfate (14808-79-8)	mg/kg	237	469	566	DOE/RL-92-24, V.1, Rev.4

~ = Not reported.
(a) Insufficient information available from the random sampling. Range results from the judgmental samples is provided.
All of the nuclides are in approximate secular equilibrium with the long-lived parent (i.e., U-238, U-235, or Th-232). This means the soil concentrations of the progeny are nearly the same as the parent.
Soil concentration values are from DOE/RL-96-12. Radionuclides marked with an asterisk are not listed in DOE/RL-96-12. The numbers shown assume secular equilibrium with the long-lived parent nuclide.

Table 3-2. Summary of Exposure Factors for Direct-Contact Soil Risk-Based Concentrations.

Parameter	Symbol	Units	WAC Industrial Land Use[a]
Target risk	TR	Unitless	$1x10^{-5}$
Target hazard quotient	THQ	Unitless	1
Oral reference dose	RfD_o	mg/kg-day	chemical specific
Oral cancer potency factor	CPF_o	kg-day/mg	chemical specific
Unit conversion factor	UCF	mg/kg	$1.00x10^{-6}$ kg/mg
Body weight–child and adult average	BW_a	Kg	70
Carcinogenic averaging time	ATC	Years	75
Noncarcinogenic averaging time	ATN	Years	20
Exposure frequency	EF	Days/year	NA
Exposure duration	ED	Years	20
Incidental soil ingestion rate	SIR	mg/day	50
Gastrointestinal absorption factor	ABS_{gi}	Unitless	1

[a]WAC 173-340-745, "Soil Cleanup Standards for Industrial Properties" (equations 745-1 and 745-2).

Table 3-3a. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Inorganic Metals (mg/kg)								
Aluminum	10,100	1.8 [6.0] - 2.1 [7.0]	11,800	No	Not Evaluated	No	No	Less than background
Antimony	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Arsenic	12.2	2.6 [8.5] - 2.9 [9.5]	6.47	Yes	8.80E+01	No	No	Less than cleanup level
Barium	118	1.8 [6.0] - 2.1 [7.0]	132	No	Not Evaluated	No	No	Less than background
Beryllium	0.626	1.2 [4.0] - 2.0 [6.5]	1.51	No	Not Evaluated	No	No	Less than background
Bismuth	0.766	1.2 [4.0] - 2.0 [6.5]	NA	No background	--	No	Yes	Detected, no background or cleanup level
Boron	3.4	1.2 [4.0] - 1.5 [5.0]	NA	No background	7.00E+05	No	No	Less than cleanup level
Cadmium	28	1.2 [4.0] - 1.5 [5.0]	1	Yes	3.50E+03	No	No	Less than cleanup level
Calcium	24,300	1.8 [6.0] - 2.1 [7.0]	17,200	Yes	--	No	No	Essential nutrient and not significantly greater than background
Chromium (total)[d]	36.8	1.2 [4.0] - 1.5 [5.0]	18.5	Yes	5.30E+06	No	No	Less than cleanup level
Chromium VI	8.8	2.3 [7.5] - 2.6 [8.5]	NA	No background	1.10E+04	No	No	Less than cleanup level
Copper	172	1.2 [4.0] - 1.5 [5.0]	22	Yes	1.30E+05	No	No	Less than cleanup level

Table 3-3a. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Iron	26,900	1.5 [5.0] - 1.8 [6.0]	32,600	No	Not Evaluated	No	No	Less than background
Lead	390	2.3 [7.5] - 2.6 [8.5]	10.2	Yes	1.00E+03	No	No	Less than cleanup level
Magnesium	4,310	1.2 [4.0] - 2.0 [6.5]	7,060	No	Not Evaluated	No	No	Less than background
Manganese	454	1.8 [6.0] - 2.1 [7.0]	512	No	Not Evaluated	No	No	Less than background
Mercury	5.2	1.2 [4.0] - 1.5 [5.0]	0.33	Yes	1.10E+03	No	No	Less than cleanup level
Molybdenum	3.2	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.80E+04	No	No	Less than cleanup level
Nickel	27.6	1.2 [4.0] - 1.5 [5.0]	19.1	Yes	7.00E+04	No	No	Less than cleanup level
Potassium	2,260	1.8 [6.0] - 2.1 [7.0]	2,150	Yes	--	No	No	Essential nutrient and within background range
Selenium	2.52	2.7 [9.0] - 3.5 [11.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Silver	42	1.2 [4.0] - 1.5 [5.0]	0.73	Yes	1.80E+04	No	No	Less than cleanup level
Sodium	873	1.2 [4.0] - 1.5 [5.0]	690	Yes	--	No	No	Essential nutrient and within background range
Thallium	0.52	1.8 [6.0] - 2.1 [7.0]	NA	No background	2.50E+02	No	No	Less than cleanup level

Table 3-3a. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Tin	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Uranium	5.28	2.3 [7.5] - 2.6 [8.5]	3.21	Yes	1.10E+04	No	No	Less than cleanup level
Vanadium	104	2.3 [7.5] - 2.6 [8.5]	85.1	Yes	2.50E+04	No	No	Less than cleanup level
Zinc	224	1.2 [4.0] - 1.5 [5.0]	67.8	Yes	1.10E+06	No	No	Less than cleanup level
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3	41.7	1.2 [4.0] - 1.5 [5.0]	9.23	Yes	--	No	Yes	Exceeds background, no cleanup level
Bromide	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Chloride	226	1.2 [4.0] - 1.5 [5.0]	100	Yes	--	No	Yes	Exceeds background, no cleanup level
Cyanide	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Fluoride	5.26	2.7 [9.0] - 3.5 [11.5]	2.81	Yes	2.10E+05	No	No	Less than cleanup level
Hydrazine	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Nitrate as N[e]	208.575	1.2 [4.0] - 1.5 [5.0]	52	Yes	3.50E+05	No	No	Less than cleanup level
Nitrite as N[e]	ND	~	~	No background	--	No	No	Not detected at waste site or no laboratory analysis conducted
Nitrate/nitrite as N[f]	210	1.2 [4.0] - 1.5 [5.0]	NA	No background	--	No	No	Detected, no background or cleanup level

Table 3-3a. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Phosphate	ND	~	0.785	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Sulfate	2,970	1.2 [4.0] - 1.5 [5.0]	237	Yes	--	No	Yes	Exceeds background, no cleanup level
Sulfide	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Organic Compounds (µg/kg)								
1,2-Dichloroethane	13	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.40E+06	No	No	Less than cleanup level
2-Butanone	ND	~	NA	No background	2.10E+09	No	No	Not detected at waste site or no laboratory analysis conducted
Acetone	30	2.3 [7.5] - 2.6 [8.5]	NA	No background	3.50E+08	No	No	Less than cleanup level
Aroclor-1254	9,400	1.2 [4.0] - 1.5 [5.0]	NA	No background	7.00E+04	No	No	Less than cleanup level
Benzo(a)anthracene	180	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.80E+04	No	No	Less than cleanup level
Benzo(a)pyrene	160	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.80E+04	No	No	Less than cleanup level
Benzo(b)fluoranthene	240	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.80E+04	No	No	Less than cleanup level
Bis(2-ethylhexyl)phthalate	6,200	1.2 [4.0] - 1.5 [5.0]	NA	No background	9.40E+06	No	No	Less than cleanup level
Butyl benzyl phthalate	290	1.2 [4.0] - 1.5 [5.0]	NA	No background	7.00E+08	No	No	Less than cleanup level

Table 3-3a. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Chrysene	210	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.80E+04	No	No	Less than cleanup level
Dibutyl phthalate	2,741	1.2 [4.0] - 1.5 [5.0]	NA	No background	3.50E+08	No	No	Less than cleanup level
Diethyl phthalate	330	2.7 [9.0] - 3.5 [11.5]	NA	No background	2.80E+09	No	No	Less than cleanup level
Fluoranthene	370	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.40E+08	No	No	Less than cleanup level
Kerosene range TPH	440,000	1.2 [4.0] - 2.0 [6.5]	NA	No background	2.00E+06	No	No	Less than cleanup level
Mesityl oxide	390	2.7 [9.0] - 3.5 [11.5]	NA	No background	--	No	Yes	Detected, no background or cleanup level
Methylene chloride	78	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.80E+07	No	No	Less than cleanup level
Motor oil TPH	760,000	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.00E+06	No	No	Less than cleanup level
N-Butylbenzenesulfonamide	4,400	2.7 [9.0] - 3.5 [11.5]	NA	No background	--	No	Yes	Detected, no background or cleanup level
Phenanthrene[g]	370	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.10E+09	No	No	Less than cleanup level
Pyrene	350	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.10E+08	No	No	Less than cleanup level
Tetrachloroethylene	6	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.40E+05	No	No	Less than cleanup level

Table 3-3a. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Toluene	ND	~	NA	No background	2.80E+08	No	No	Not detected at waste site or no laboratory analysis conducted
Tributyl phosphate[h]	543	1.2 [4.0] - 2.0 [6.5]	NA	No background	2.43E+07	No	No	Less than cleanup level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).

[c]The industrial direct exposure cleanup levels reported in this table are the most conservative Method C standard formula values reported in the CLARC online database as of 2/6/07. Where Method C values were unavailable, this table defers to the Method A industrial land use values reported in the CLARC online database (2/6/07) and in Table 745-1 of the MTCA Cleanup Regulation (WAC 173-340-900).

[d] Maximum detected total chromium values were instead compared to chromium III Method C levels as reported in the CLARC online database as of 2/6/07.

[e]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[f]Nitrate/nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.

[g]A cleanup level for this constituent was unavailable, so the cleanup level for anthracene was used.

[h]A cleanup level for this constituent was unavailable, so one was calculated using MTCA Cleanup Regulation (WAC 173-340) equations 745-1 and 745-2. The lowest calculated cleanup level (for carcinogenic health effects) is shown here.

COC = Contaminant of Concern.

bgs = below ground surface.

ND = not detected.

NA = no background value available.

-- = no cleanup level is available.

Shading indicates that the chemical was retained as a contaminant of concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-3b. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Inorganic Metals (mg/kg)								
Aluminum	7,090	3.2 [10.5] - 4.0 [13.0]	11,800	No	Not Evaluated	No	No	Less than background
Antimony	5	1.2 [4.0] - 2.0 [6.5]	NA	No background	1.40E+03	No	No	Less than cleanup level
Arsenic	5.1	4.6 [15.0] - 5.2 [17.0]	6.47	No	Not Evaluated	No	No	Less than background
Barium	96.9	2.3 [7.5] - 2.6 [8.5]	132	No	Not Evaluated	No	No	Less than background
Beryllium	0.713	3.8 [12.5] - 4.4 [14.5]	1.51	No	Not Evaluated	No	No	Less than background
Bismuth	37.1	2.4 [8.0] - 3.2 [10.5]	NA	No background	--	No	Yes	Detected, no background or cleanup level
Boron	6.3	2.4 [8.0] - 3.2 [10.5]	NA	No background	7.00E+05	No	No	Less than cleanup level
Cadmium	0.27	1.5 [5.0] - 1.8 [6.0]	1	No	Not Evaluated	No	No	Less than background
Calcium	8,760	2.4 [8.0] - 3.2 [10.5]	17,200	No	Not Evaluated	No	No	Less than background
Chromium (total)[d]	21.9	3.8 [12.5] - 4.4 [14.5]	18.5	Yes	5.30E+06	No	No	Less than cleanup level
Chromium VI	0.45	2.9 [9.5] - 3.2 [10.5]	NA	No background	1.10E+04	No	No	Less than cleanup level
Cobalt	11.4	2.4 [8.0] - 3.2 [10.5]	15.7	No	Not Evaluated	No	No	Less than background
Copper	30.6	3.7 [12.0] - 4.0 [13.0]	22	Yes	1.30E+05	No	No	Less than cleanup level

Table 3-3b. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Iron	28,400	1.8 [6.0] - 2.1 [7.0]	32,600	No	Not Evaluated	No	No	Less than background
Lead	7.5	2.4 [8.0] - 3.2 [10.5]	10.2	No	Not Evaluated	No	No	Less than background
Magnesium	4,930	1.8 [6.0] - 2.1 [7.0]	7,060	No	Not Evaluated	No	No	Less than background
Manganese	410	1.8 [6.0] - 2.1 [7.0]	512	No	Not Evaluated	No	No	Less than background
Mercury	0.15	4.0 [13.0] - 4.7 [15.5]	0.33	No	Not Evaluated	No	No	Less than background
Molybdenum	0.55	1.5 [5.0] - 1.8 [6.0]	NA	No background	1.80E+04	No	No	Less than cleanup level
Nickel	15	3.8 [12.5] - 4.4 [14.5]	19.1	No	Not Evaluated	No	No	Less than background
Potassium	1,740	1.5 [5.0] - 1.8 [6.0]	2,150	No	Not Evaluated	No	No	Less than background
Selenium	0.75	2.3 [7.5] - 2.6 [8.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Silver	0.86	2.4 [8.0] - 3.2 [10.5]	0.73	Yes	1.80E+04	No	No	Less than cleanup level
Sodium	671	3.2 [10.5] - 4.0 [13.0]	690	No	Not Evaluated	No	No	Less than background
Thallium	0.53	1.8 [6.0] - 2.1 [7.0]	NA	No background	2.50E+02	No	No	Less than cleanup level
Tin	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Uranium	2.38	4.0 [13.0] - 4.7 [15.5]	3.21	No	Not Evaluated	No	No	Less than background

Table 3-3b. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Vanadium	86.9	2.3 [7.5] - 2.6 [8.5]	85.1	Yes	2.50E+04	No	No	Less than cleanup level
Zinc	80.8	3.7 [12.0] - 4.0 [13.0]	67.8	Yes	1.10E+06	No	No	Less than cleanup level
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3[e]	9.99	4.6 [15.0] - 5.2 [17.0]	9.23	No	--	No	No	Less than background
Chloride	17.9	1.5 [5.0] - 1.8 [6.0]	100	No	Not Evaluated	No	No	Less than background
Cyanide	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Fluoride	0.76	2.3 [7.5] - 2.6 [8.5]	2.81	No	Not Evaluated	No	No	Less than background
Hydrazine	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Nitrate as N[f]	187.425	1.5 [5.0] - 1.8 [6.0]	52	Yes	3.50E+05	No	No	Less than cleanup level
Nitrite as N[f]	0.380	1.2 [4.0] - 2.0 [6.5]	NA	No background	3.50E+05	No	No	Less than cleanup level
Nitrate/nitrite as N[g]	69.92	1.5 [5.0] - 1.8 [6.0]	NA	No background	--	No	No	Detected, no background or cleanup level
Phosphate	6.4	2.1 [7.0] - 2.4 [8.0]	0.785	Yes	--	No	Yes	Exceeds background, no cleanup level
Sulfate	76.2	1.5 [5.0] - 1.8 [6.0]	237	No	Not Evaluated	No	No	Less than background
Sulfide	43.8	3.4 [11.0] - 3.7 [12.0]	NA	No background	--	No	Yes	Detected, no background or cleanup level

Table 3-3b. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Organic Compounds (µg/kg)								
1,2,4-Trimethylbenzene	NLA	~	NA	No background	1.80E+08	No	No	Not detected at waste site or no laboratory analysis conducted
2-Ethylhexanol	6	4.0 [13.0] - 4.7 [15.5]	NA	No background	--	No	Yes	Detected, no background or cleanup level
Acetone	66	1.5 [5.0] - 1.8 [6.0]	NA	No background	3.50E+08	No	No	Less than cleanup level
Aroclor-1254	77	3.0 [10.0] - 4.0 [13.0]	NA	No background	7.00E+04	No	No	Less than cleanup level
Aroclor-1260[h]	9,200	2.4 [8.0] - 3.2 [10.5]	NA	No background	6.60E+04	No	No	Less than cleanup level
Benzene	8	1.5 [5.0] - 1.8 [6.0]	NA	No background	2.40E+06	No	No	Less than cleanup level
Bis(2-ethylhexyl) phthalate	21	2.4 [8.0] - 2.9 [9.5]	NA	No background	9.40E+06	No	No	Less than cleanup level
Butyl benzyl phthalate	ND	~	NA	No background	7.00E+08	No	No	Not detected at waste site or no laboratory analysis conducted
Dibutyl phthalate	ND	~	NA	No background	3.50E+08	No	No	Not detected at waste site or no laboratory analysis conducted
Diethyl phthalate	ND	~	NA	No background	2.80E+09	No	No	Not detected at waste site or no laboratory analysis conducted
Di-n-octyl phthalate	52	4.0 [13.0] - 4.7 [15.5]	NA	No background	7.00E+07	No	No	Less than cleanup level
Hexadecanoic acid (9CI)	NLA	~	NA	No background	--	No	No	Not detected at waste site or no laboratory analysis conducted
Methylene chloride	27	2.9 [9.5] - 3.2 [10.5]	NA	No background	1.80E+07	No	No	Less than cleanup level

Table 3-3b. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Octadecanoic acid	NLA	~	NA	No background	--	No	No	Not detected at waste site or no laboratory analysis conducted
Toluene	3	2.1 [7.0] - 2.4 [8.0]	NA	No background	2.80E+08	No	No	Less than cleanup level
Xylenes (total)	ND	~	NA	No background	7.00E+08	No	No	Not detected at waste site or no laboratory analysis conducted

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).

[c]The industrial direct exposure cleanup levels reported in this table are the most conservative Method C standard formula values reported in the CLARC online database as of 2/6/07. Where Method C values were unavailable, this table defers to the Method A industrial land use values reported in the CLARC online database (2/6/07) and in Table 745-1 of the MTCA Cleanup Regulation (WAC 173-340-900).

[d]Maximum detected total chromium values were instead compared to chromium III Method C values as reported in the CLARC online database as of 2/6/07.

[e]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[f]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[g]Nitrate/nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.

[h]A cleanup level for this constituent was unavailable, so the cleanup level for PCB was used for this constituent.

COC = Contaminant of Concern.
bgs = below ground surface.
ND = not detected.
NLA = no laboratory analysis conducted.
NA = no background value available.
-- = no cleanup level is available.
Shading indicates that the chemical was retained as a contaminant of concern.
Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-3c. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Inorganic Metals (mg/kg)								
Aluminum	10,800	0.0 [0.0] - 0.5 [1.5]	11,800	No	Not Evaluated	No	No	Less than background
Arsenic	5.5	2.6 [8.5] - 2.9 [9.5]	6.47	No	Not Evaluated	No	No	Less than background
Barium	120	0.9 [3.0] - 1.2 [4.0]	132	No	Not Evaluated	No	No	Less than background
Beryllium	0.5	2.0 [6.5] - 2.7 [9.0]	1.51	No	Not Evaluated	No	No	Less than background
Bismuth	2	0.0 [0.0] - 0.5 [1.5]	NA	No background	--	No	Yes	Detected, no background or cleanup level
Boron	1.5	0.0 [0.0] - 0.5 [1.5]; 1.8 [6.0] - 2.1 [7.0]	NA	No background	7.00E+05	No	No	Less than cleanup level
Cadmium	0.48	0.0 [0.0] - 0.5 [1.5]	1	No	Not Evaluated	No	No	Less than background
Calcium	3,880	0.9 [3.0] - 1.2 [4.0]	17,200	No	Not Evaluated	No	No	Less than background
Chromium (total)[d]	815	0.0 [0.0] - 0.5 [1.5]	18.5	Yes	5.30E+06	No	No	Less than cleanup level
Chromium VI	14.1	0.5 [1.5] - 0.9 [3.0]	NA	No background	1.10E+04	No	No	Less than cleanup level
Copper	244	0.0 [0.0] - 0.5 [1.5]	22	Yes	1.30E+05	No	No	Less than cleanup level

Table 3-3c. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Iron	28,800	0.0 [0.0] - 0.5 [1.5]	32,600	No	Not Evaluated	No	No	Less than background
Lead	30	0.0 [0.0] - 0.5 [1.5]	10.2	Yes	1.00E+03	No	No	Less than cleanup level
Magnesium	4,370	0.9 [3.0] - 1.2 [4.0]	7,060	No	Not Evaluated	No	No	Less than background
Manganese	451	0.9 [3.0] - 1.2 [4.0]	512	No	Not Evaluated	No	No	Less than background
Mercury	4.3	0.0 [0.0] - 0.5 [1.5]	0.33	Yes	1.10E+03	No	No	Less than cleanup level
Molybdenum	0.88	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Nickel	20.3	0.0 [0.0] - 0.5 [1.5]	19.1	Yes	7.00E+04	No	No	Less than cleanup level
Potassium	856	0.9 [3.0] - 1.2 [4.0]	2,150	No	Not Evaluated	No	No	Less than background
Selenium	0.44	2.6 [8.5] - 2.9 [9.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Silver	30.4	0.0 [0.0] - 0.5 [1.5]	0.73	Yes	1.80E+04	No	No	Less than cleanup level
Sodium	176	0.0 [0.0] - 0.5 [1.5]	690	No	Not Evaluated	No	No	Less than background
Thallium	0.99	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.50E+02	No	No	Less than cleanup level

Table 3-3c. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Uranium	1.49	2.6 [8.5] - 2.9 [9.5]	3.21	No	Not Evaluated	No	No	Less than background
Vanadium	87.5	2.6 [8.5] - 2.9 [9.5]	85.1	Yes	2.50E+04	No	No	Less than cleanup level
Zinc	506	0.0 [0.0] - 0.5 [1.5]	67.8	Yes	1.10E+06	No	No	Less than cleanup level
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3	ND	~	9.23	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Chloride	11.5	2.4 [8.0] - 2.7 [9.0]	100	No	Not Evaluated	No	No	Less than background
Cyanide	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Fluoride	0.7	2.6 [8.5] - 2.9 [9.5]	2.81	No	Not Evaluated	No	No	Less than background
Nitrate as N[e]	18.135	0.0 [0.0] - 0.5 [1.5]	12	Yes	3.50E+05	No	No	Less than cleanup level
Nitrite as N[e]	0.3496	2.6 [8.5] - 2.9 [9.5]	NA	No background	3.50E+05	No	No	Less than cleanup level
Nitrate/nitrite as N[f]	10.6	0.0 [0.0] - 0.5 [1.5]	NA	No background	--	No	No	Detected, no background or cleanup level
Phosphate[g]	1.5	0.9 [3.0] - 1.2 [4.0]	0.785	No	--	No	No	Less than background

Table 3-3c. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Sulfate	199	0.0 [0.0] - 0.5 [1.5]	237	No	Not Evaluated	No	No	Less than background
Sulfide	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Organic Compounds (µg/kg)								
Acenaphthene	61	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.10E+08	No	No	Less than cleanup level
Acetone	9	4.1 [13.5] - 4.4 [14.5]	NA	No background	3.50E+08	No	No	Less than cleanup level
Anthracene	150	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.10E+09	No	No	Less than cleanup level
Aroclor-1254	3,700	0.0 [0.0] - 0.5 [1.5]	NA	No background	7.00E+04	No	No	Less than cleanup level
Benzo(a)anthracene	550	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Benzo(a)pyrene	600	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Benzo(b)fluoranthene	530	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Benzo(g,h,i)perylene[h]	660	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.10E+08	No	No	Less than cleanup level
Benzo(k)fluoranthene	450	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Bis(2-ethylhexyl) phthalate	580	0.0 [0.0] - 0.5 [1.5]	NA	No background	9.40E+06	No	No	Less than cleanup level

Table 3-3c. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Butyl benzyl phthalate	580	0.0 [0.0] - 0.5 [1.5]	NA	No background	7.00E+08	No	No	Less than cleanup level
Butyl stearate	NLA	~	NA	No background	--	No	No	Not detected at waste site or no laboratory analysis conducted
Carbazole	97	0.0 [0.0] - 0.5 [1.5]	NA	No background	6.60E+06	No	No	Less than cleanup level
Chrysene	680	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Dibenzo(a,h)anthracene	110	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Dibutyl phthalate	2,300	0.0 [0.0] - 0.5 [1.5]	NA	No background	3.50E+08	No	No	Less than cleanup level
Diesel Range TPH	31,000	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.00E+06	No	No	Less than cleanup level
Diethyl phthalate	ND	~	NA	No background	2.80E+09	No	No	Not detected at waste site or no laboratory analysis conducted
Eicosane	NLA	~	NA	No background	--	No	No	Not detected at waste site or no laboratory analysis conducted
Fluoranthene	1,500	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.40E+08	No	No	Less than cleanup level
Fluorene	59	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.40E+08	No	No	Less than cleanup level
Hexadecanoic acid, butyl ester	NLA	~	NA	No background	--	No	No	Not detected at waste site or no laboratory analysis conducted
Indeno(1,2,3-cd)pyrene	400	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.80E+04	No	No	Less than cleanup level

Table 3-3c. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (6 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Methylene chloride	10	--	NA	No background	1.80E+07	No	No	Less than cleanup level
Phenanthrene[i]	930	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.10E+09	No	No	Less than cleanup level
Pyrene	1,600	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.10E+08	No	No	Less than cleanup level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).

[c]The industrial direct exposure cleanup levels reported in this table are the most conservative Method C standard formula values reported in the CLARC online database as of 2/6/07. Where Method C values were unavailable, this table defers to the Method A industrial land use values reported in the CLARC online database (2/6/07) and in Table 745-1 of the MTCA Cleanup Regulation (WAC 173-340-900).

[d]Maximum detected total chromium values were instead compared to chromium III Method C values as reported in the CLARC online database as of 2/6/07.

[e]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[f]Nitrate/nitritie as N was not evaluated because the total nitrite concentrations have their own criterion.

[g] Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[h]A cleanup level for this constituent was unavailable, so the cleanup level for pyrene was used.

[i]A cleanup level for this constituent was unavailable, so the cleanup level for anthracene was used.

COC= Contaminant of Concern

bgs = below ground surface.

ND = not detected.

NLA = no laboratory analysis conducted.

NA = no background value available.

-- = no cleanup level is available.

Shading indicates that the chemical was retained as a contaminant of concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-3d. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (5 sheets)

Constituent Name[a]	**Maximum Detected Concentration from 0 to 4.6 m**[b]	**Depth of Maximum Detected from 0 to 4.6 m [ft] bgs**	**90th Percentile Background Concentration**	**Does Maximum Detected from 0 to 4.6 m Exceed Background?**	**Industrial Direct Exposure Cleanup Level**[c]	**Does Maximum Detected Exceed cleanup Level?**	**COC?**	**Justification**
Inorganic Metals (mg/kg)								
Aluminum	5,870	1.8 [6.0] - 2.1 [7.0]	11,800	No	Not Evaluated	No	No	Less than background
Arsenic	5.6	2.0 [6.5] - 2.3 [7.5]	6.47	No	Not Evaluated	No	No	Less than background
Barium	103	4.3 [14.0] - 4.6 [15.0]	132	No	Not Evaluated	No	No	Less than background
Beryllium	0.42	1.2 [4.0] - 1.5 [5.0]	1.51	No	Not Evaluated	No	No	Less than background
Bismuth	ND	~	NA	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Boron	1	1.8 [6.0] - 2.1 [7.0]	NA	No background	7.00E+05	No	No	Less than cleanup level
Cadmium	0.2	2.7 [9.0] - 3.0 [10.0]	1	No	Not Evaluated	No	No	Less than background
Calcium	11,100	1.2 [4.0] - 1.5 [5.0]	17,200	No	Not Evaluated	No	No	Less than background
Chromium (total)[d]	26.2	2.7 [9.0] - 3.0 [10.0]; 3.4 [11.0] - 3.7 [12.0]	18.5	Yes	5.30E+06	No	No	Less than cleanup level

Table 3-3d. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Chromium VI	2.7	2.1 [7.0] - 2.4 [8.0]	NA	No background	1.10E+04	No	No	Less than cleanup level
Copper	17.7	2.0 [6.5] - 2.3 [7.5];2.9 [9.5] - 32. [10.5]	22	No	Not Evaluated	No	No	Less than background
Iron	25,100	1.2 [4.0] - 1.5 [5.0]; 1.8 [6.0] - 2.1 [7.0]	32,600	No	Not Evaluated	No	No	Less than background
Lead	5.4	1.8 [6.0] - 2.1 [7.0]	10.2	No	Not Evaluated	No	No	Less than background
Magnesium	4,780	1.2 [4.0] - 1.5 [5.0]	7,060	No	Not Evaluated	No	No	Less than background
Manganese	392	1.8 [6.0] - 2.1 [7.0]	512	No	Not Evaluated	No	No	Less than background
Mercury	0.43	3.5 [11.5] - 3.8 [12.5]	0.33	Yes	1.10E+03	No	No	Less than cleanup level
Molybdenum	0.29	2.0 [6.5] - 2.3 [7.5]	NA	No background	1.80E+04	No	No	Less than cleanup level
Nickel	12	2.0 [6.5] - 2.3 [7.5]	19.1	No	Not Evaluated	No	No	Less than background
Potassium	1,230	1.8 [6.0] - 2.1 [7.0]	2,150	No	Not Evaluated	No	No	Less than background

Table 3-3d. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Selenium	0.46	2.7 [9.0] - 3.0 [10.0]	NA	No background	1.80E+04	No	No	Less than cleanup level
Silver	8.3	2.7 [9.0] - 3.0 [10.0]	0.73	Yes	1.80E+04	No	No	Less than cleanup level
Sodium	193	2.0 [6.5] - 2.3 [7.5]	690	No	Not Evaluated	No	No	Less than background
Thallium	0.62	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.50E+02	No	No	Less than cleanup level
Uranium	2.01	2.9 [9.5] - 3.2 [10.5]	3.21	No	Not Evaluated	No	No	Less than background
Vanadium	81.7	2.9 [9.5] - 3.2 [10.5]	85.1	No	Not Evaluated	No	No	Less than background
Zinc	59.7	2.9 [9.5] - 3.2 [10.5]	67.8	No	Not Evaluated	No	No	Less than background
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3	ND	~	9.23	No	Not Evaluated	No	No	Not detected at waste site or no laboratory analysis conducted
Chloride	3.1	2.9 [9.5] - 3.2 [10.5]	100	No	Not Evaluated	No	No	Less than background
Cyanide	0.2	2.9 [9.5] - 3.2 [10.5]	NA	No background	7.00E+04	No	No	Less than cleanup level
Fluoride	1.1	2.9 [9.5] - 3.2 [10.5]	2.81	No	Not Evaluated	No	No	Less than background

Table 3-3d. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Nitrate as N[e]	10.125	2.0 [6.5] - 2.3 [7.5]	52	No	Not Evaluated	No	No	Less than background
Nitrite as N[e]	0.48032	2.9 [9.5] - 3.2 [10.5]	NA	No background	3.50E+05	No	No	Less than cleanup level
Nitrate/nitrite as N[f]	14.9	2.0 [6.5] - 2.3 [7.5]	NA	No background	--	No	No	Detected, no background or cleanup level
Phosphate[g]	3.8	3.5 [11.5] - 3.8 [12.5]	0.785	No	--	No	No	Less than background
Sulfate	11.5	2.0 [6.5] - 2.3 [7.5]	237	No	Not Evaluated	No	No	Less than background
Sulfide	59	3.4 [11.0] - 3.7 [12.0]	NA	No background	--	No	Yes	Detected, no background or cleanup level
Organic Compounds (μg/kg)								
2-Butanone	ND	~	NA	No background	2.10E+09	No	No	Not detected at waste site or no laboratory analysis conducted
Acetone	26	2.6 [8.5] - 2.9 [9.5]	NA	No background	3.50E+08	No	No	Less than cleanup level
Bis(2-ethylhexyl) phthalate	140	1.2 [4.0] - 1.5 [5.0]	NA	No background	9.40E+06	No	No	Less than cleanup level
Dibutyl phthalate	ND	~	NA	No background	3.50E+08	No	No	Not detected at waste site or no laboratory analysis conducted

Table 3-3d. Human Health Cleanup Levels and Contaminants of Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 to 4.6 m[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Detected from 0 to 4.6 m Exceed Background?	Industrial Direct Exposure Cleanup Level[c]	Does Maximum Detected Exceed cleanup Level?	COC?	Justification
Methylene chloride	15	2.9 [9.5] - 3.2 [10.5]	NA	No background	1.80E+07	No	No	Less than cleanup level
Toluene	4.2	2.9 [9.5] - 3.2 [10.5]	NA	No background	2.80E+08	No	No	Less than cleanup level
Xylenes (total)	1.388	1.8 [6.0] - 2.1 [7.0]	NA	No background	7.00E+08	No	No	Less than cleanup level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).

[c]The industrial direct exposure cleanup levels reported in this table are the most conservative Method C standard formula values reported in the CLARC online database as of 2/6/07. Where Method C values were unavailable, this table defers to the Method A industrial land use values reported in the CLARC online database (2/6/07) and in Table 745-1 of the MTCA Cleanup Regulation (WAC 173-340-900).

[d] Maximum detected total chromium values were instead compared to chromium III Method C values as reported in the CLARC online database as of 2/6/07.

[e]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[f]Nitrate/nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.

[g]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

COC= Contaminant of Concern

bgs = below ground surface.

ND = not detected.

NA = no background value available.

-- = no cleanup level is available.

Shading indicates that the chemical was retained as a contaminant of concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-4. Human Health Background Comparison for Radionuclides in Shallow-Zone Soils (0 m to 4.6 m [15 ft]) Across All Waste Sites. (5 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 to 4.6 m [15 ft] (pCi/g)	Depth of Maximum Detected Concentration m [ft] bgs
216-A-29 Ditch			
Actinium-228[c]	1.32	0.429	2.7 [9.0] - 3.5 [11.5]
Americium-241	NA	145	1.2 [4.0] - 2.0 [6.5]
Antimony-125	NA	1.67	1.2 [4.0] - 1.5 [5.0]
Barium-133	NA	ND	~
Bismuth-212[c]	NA	0.282	2.7 [9.0] - 3.5 [11.5]
Bismuth-214[c]	NA	0.392	2.7 [9.0] - 3.5 [11.5]
Carbon-14	NA	ND	~
Cerium-144[c]	NA	ND	~
Cesium-134	NA	ND	~
Cesium-137	1.05	98.4	1.2 [4.0] - 1.5 [5.0]
Cobalt-60	0.00842	ND	~
Curium-242[c]	NA	ND	~
Curium-243/244	NA	ND	~
Europium-152	NA	ND	~
Europium-154	0.0334	ND	~
Europium-155	0.0539	0.05	3.0 [10.0]
Lead-212[c]	NA	0.445	2.7 [9.0] - 3.5 [11.5]
Lead-214[c]	NA	0.432	2.7 [9.0] - 3.5 [11.5]
Neptunium-237	NA	0.124	3.5 [11.5] - 3.8 [12.5]
Nickel-63	NA	ND	~
Niobium-94	NA	ND	~
Plutonium-238	0.00378	15.7	1.2 [4.0] - 2.0 [6.5]
Plutonium-239/240	0.0248	667	1.2 [4.0] - 2.0 [6.5]
Potassium-40	16.6	16	1.8 [6.0] - 2.1 [7.0]
Radium-226[d,f]	0.815	0.895	2.6 [8.5] - 2.9 [9.5]
Radium-228[d, f]	1.32	1.11	1.8 [6.0] - 2.1 [7.0]
Ruthenium-103[c]	NA	ND	~
Ruthenium-106	NA	ND	~
Sodium-22	NA	ND	~
Strontium-90[a]	0.178	0.779	3.0 [10.0] - 3.4 [11.0]
Technetium-99	NA	ND	~
Thallium-208[c]	NA	0.136	2.7 [9.0] - 3.5 [11.5]
Thorium-228[d]	1.32	1.14	3.0 [10.0] - 3.4 [11.0]
Thorium-230[d]	1.1	1.49	2.7 [9.0] - 3.5 [11.5]
Thorium-232[d]	1.32	1.22	3.0 [10.0] - 3.4 [11.0]
Thorium-234[c]	NA	ND	~
Tin-113[c]	NA	ND	~
Tin-126	NA	ND	~
Tritium	NA	ND	~
Uranium-233/234[b]	1.1	2.31	2.3 [7.5] - 2.6 [8.5]
Uranium-234	1.1	0.964	3.0 [10.0] - 3.4 [11.0]
Uranium-235	0.109	0.439	1.2 [4.0] - 1.5 [5.0]

Table 3-4. Human Health Background Comparison for Radionuclides in Shallow-Zone Soils (0 m to 4.6 m [15 ft]) Across All Waste Sites. (5 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 to 4.6 m [15 ft] (pCi/g)	Depth of Maximum Detected Concentration m [ft] bgs
Uranium-238	1.06	1.81	2.3 [7.5] - 2.6 [8.5]
Zinc-65[c]	NA	ND	~
216-B-63 Trench			
Actinium-228[c]	1.32	NLA	~
Americium-241	NA	0.589	2.4 [8.0] - 3.2 [10.5]
Antimony-125	NA	ND	~
Barium-133	NA	ND	~
Bismuth-212[c]	NA	NLA	~
Bismuth-214[c]	NA	NLA	~
Carbon-14	NA	ND	~
Cerium-144[c]	NA	NLA	~
Cesium-134	NA	ND	~
Cesium-137	1.05	100	4.0 [13.0] - 4.7 [15.5]
Cobalt-60	0.00842	ND	~
Curium-242[c]	NA	ND	~
Curium-243/244	NA	ND	~
Curium-244	NA	ND	~
Europium-152	NA	ND	~
Europium-154	0.0334	1.29	2.4 [8.0] - 3.2 [10.5]
Europium-155	0.0539	ND	~
Iodine-129	NA	ND	~
Lead-212[c]	NA	NLA	~
Lead-214[c]	NA	NLA	~
Neptunium-237	NA	0.054	2.9 [9.5] - 3.2 [10.5]
Nickel-63	NA	NLA	~
Niobium-94	NA	NLA	~
Plutonium-238	0.00378	ND	~
Plutonium-239/240	0.0248	4.97	4.0 [13.0] - 4.7 [15.5]
Plutonium-241	NA	ND	~
Potassium-40	16.6	15	1.2 [4.0] - 2.0 [6.5]
Radium-224[c]	NA	0.91	1.2 [4.0] - 2.0 [6.5]
Radium-226[d]	0.815	0.762	1.2 [4.0] - 2.0 [6.5]
Radium-228[d]	1.32	0.917	1.2 [4.0] - 2.0 [6.5]
Ruthenium-103[c]	NA	NLA	~
Ruthenium-106	NA	NLA	~
Selenium-79	NA	ND	~
Sodium-22	NA	ND	~
Strontium-90[a]	0.178	4,710	4.0 [13.0] - 4.7 [15.5]
Technetium-99[e]	NA	ND	~
Thallium-208[c]	NA	NLA	~
Thorium-228[d, f]	1.32	0.975	2.1 [7.0] - 2.4 [8.0]
Thorium-230[d]	1.1	2.67	2.4 [8.0] - 3.2 [10.5]

Table 3-4. Human Health Background Comparison for Radionuclides in Shallow-Zone Soils (0 m to 4.6 m [15 ft]) Across All Waste Sites. (5 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 to 4.6 m [15 ft] (pCi/g)	Depth of Maximum Detected Concentration m [ft] bgs
Thorium-232[d]	1.32	0.888	3.2 [10.5] - 4.0 [13.0]
Thorium-234[c]	NA	NLA	~
Tin-113[c]	NA	NLA	~
Tin-126	NA	ND	~
Tritium	NA	NLA	~
Uranium-233/234[b]	1.1	0.36	1.5 [5.0] - 1.8 [6.0]
Uranium-234	1.1	0.748	2.3 [7.5] - 2.6 [8.5]
Uranium-235	0.109	ND	~
Uranium-238	1.06	0.93	2.3 [7.5] - 2.6 [8.5]
Zinc-65[c]	NA	NLA	~
216-S-10 Ditch			
Actinium-228[c]	1.32	NLA	~
Americium-241	NA	1.84	2.0 [6.5] - 2.7 [9.0]
Antimony-125	NA	ND	~
Barium-133	NA	ND	~
Bismuth-212[c]	NA	NLA	~
Bismuth-214[c]	NA	NLA	~
Carbon-14	NA	ND	~
Cerium-144[c]	NA	NLA	~
Cesium-134	NA	ND	~
Cesium-137	1.05	9.13	0.0 [0.0] - 0.5 [1.5]
Cobalt-60	0.00842	ND	~
Curium-242[c]	NA	ND	~
Curium-243/244	NA	ND	~
Europium-152	NA	ND	~
Europium-154	0.0334	ND	~
Europium-155	0.0539	ND	~
Lead-212[c]	NA	NLA	~
Lead-214[c]	NA	NLA	~
Neptunium-237	NA	ND	~
Nickel-63	NA	NLA	~
Niobium-94	NA	NLA	~
Plutonium-238	0.00378	ND	~
Plutonium-239/240	0.0248	5.33	2.0 [6.5] - 2.7 [9.0]
Potassium-40	16.6	13.3	2.4 [8.0] - 2.7 [9.0]
Radium-226[d]	0.815	0.603	2.4 [8.0] - 2.7 [9.0]
Radium-228[d]	1.32	0.939	2.4 [8.0] - 2.7 [9.0]
Ruthenium-103[c]	NA	NLA	~
Ruthenium-106	NA	NLA	~
Sodium-22	NA	ND	~
Strontium-90[a]	0.178	0.462	0.9 [3.0] - 1.2 [4.0]
Technetium-99	NA	NLA	~

Table 3-4. Human Health Background Comparison for Radionuclides in Shallow-Zone Soils (0 m to 4.6 m [15 ft]) Across All Waste Sites. (5 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 to 4.6 m [15 ft] (pCi/g)	Depth of Maximum Detected Concentration m [ft] bgs
Thallium-208[c]	NA	NLA	~
Thorium-228[d]	1.32	0.903	2.4 [8.0] - 2.7 [9.0]
Thorium-230[d]	1.1	1.34	2.0 [6.5] - 2.7 [9.0]
Thorium-232[d]	1.32	0.939	2.4 [8.0] - 2.7 [9.0]
Thorium-234[c]	NA	NLA	~
Tin-113[c]	NA	NLA	~
Tin-126	NA	ND	~
Tritium	NA	NLA	~
Uranium-234	1.1	0.524	2.6 [8.5] - 2.9 [9.5]
Uranium-235	0.109	ND	~
Uranium-238	1.06	0.536	2.6 [8.5] - 2.9 [9.5]
Zinc-65[c]	NA	NLA	~
216-S-10 Pond			
Americium-241	NA	0.395	3.5 [11.5] - 3.8 [12.5]
Antimony-125	NA	ND	~
Barium-133	NA	ND	~
Carbon-14	NA	12.2	2.0 [6.5] - 2.3 [7.5]
Cesium-134	NA	ND	~
Cesium-137	1.05	1.77	3.5 [11.5] - 3.8 [12.5]
Cobalt-60	0.00842	ND	~
Curium-242[c]	NA	ND	~
Curium-243/244	NA	ND	~
Europium-152	NA	ND	~
Europium-154	0.0334	ND	~
Europium-155	0.0539	ND	~
Neptunium-237	NA	ND	~
Nickel-63	NA	NLA	~
Plutonium-238	0.00378	ND	~
Plutonium-239/240	0.0248	2.33	3.5 [11.5] - 3.8 [12.5]
Potassium-40	16.6	12.8	2.0 [6.5] - 2.3 [7.5];
Radium-226	0.815	0.546	1.8 [6.0] - 2.1 [7.0]
Radium-228[d]	1.32	0.878	1.2 [4.0] - 1.5 [5.0]
Sodium-22	NA	ND	~
Strontium-90[a]	0.178	1.26	2.9 [9.5] - 3.2 [10.5]
Technetium-99	NA	NLA	~
Thorium-228[d, f]	1.32	1.45	3.7 [12.0] - 4.0 [13.0]
Thorium-230[d]	1.1	1.59	4.1 [13.5] - 4.4 [14.5]
Thorium-232[d]	1.32	0.878	1.2 [4.0] - 1.5 [5.0]
Tin-126	NA	ND	~
Tritium	NA	NLA	~
Uranium-233/234[b]	1.1	NLA	~
Uranium-234	1.1	0.563	2.9 [9.5] - 3.2 [10.5]
Uranium-235	0.109	ND	~

Table 3-4. Human Health Background Comparison for Radionuclides in Shallow-Zone Soils (0 m to 4.6 m [15 ft]) Across All Waste Sites. (5 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 to 4.6 m [15 ft] (pCi/g)	Depth of Maximum Detected Concentration m [ft] bgs
Uranium-238	1.06	0.568	2.9 [9.5] - 3.2 [10.5]

[a]Analyzed as total beta radiostrontium.

[b]Uranium-233/234 evaluated as uranium-234.

[c]These radionuclides have a half-life of less than one yearvaluated.

[d]Value based on assumption of secular equilibrium with the parent nuclide.

[e]Actual concentration may reside between 0.04 and 0.4 based on QC data.

[f]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

NA = not available or not analyzed.

ND = not detected.

NLA = no laboratory analysis conducted.

Shading indicates result exceeded background concentration.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-5. Human Health Doses and Cancer Risks for the Industrial Scenario.

Time After Site Closure	216-A-29 Ditch		216-B-63 Trench		216-S-10 Ditch	216-S-10 Ponds
	Head End	Outlet End	without	with E33-333		
Radiation Dose, mrem/y						
0 y	6.69E-09	1.53E-07	9.54E-13	5.25E-11	2.28E-04	1.77E-13
50 y	2.13E-09	4.85E-08	3.03E-13	2.53E-11	7.22E-05	5.63E-14
100 y	6.87E-10	1.56E-08	9.64E-14	3.49E-11	2.29E-05	1.79E-14
150 y	2.29E-10	5.14E-09	3.07E-14	4.89E-11	7.28E-06	5.67E-15
300 y	2.70E-11	4.70E-10	9.93E-16	9.47E-11	2.33E-07	1.84E-16
500 y	3.12E-11	4.23E-10	2.53E-17	1.55E-10	2.72E-09	6.87E-18
1000 y	7.75E-11	8.99E-10	4.95E-17	2.98E-10	4.61E-10	1.39E-17
2000 y	2.11E-10	2.24E-09	2.03E-16	5.59E-10	6.09E-10	4.41E-17
5000 y	6.35E-10	5.92E-09	1.64E-15	1.25E-09	1.04E-09	1.94E-16
10000 y	1.26E-09	1.01E-08	1.07E-14	2.59E-09	2.44E-09	5.71E-16
Excess Lifetime Cancer Risk						
0 y	9.58E-14	2.19E-12	1.37E-17	6.83E-16	3.27E-09	2.55E-18
50 y	3.06E-14	6.98E-13	4.36E-18	5.10E-16	1.04E-09	8.08E-19
100 y	9.93E-15	2.25E-13	1.39E-18	7.25E-16	3.29E-10	2.57E-19
150 y	3.37E-15	7.51E-14	4.40E-19	9.99E-16	1.05E-10	8.15E-20
300 y	4.91E-16	8.31E-15	1.43E-20	1.88E-15	3.35E-12	2.66E-21
500 y	6.10E-16	8.21E-15	4.41E-22	3.02E-15	4.02E-14	1.24E-22
1000 y	1.50E-15	1.74E-14	9.59E-22	5.75E-15	8.18E-15	2.68E-22
2000 y	4.06E-15	4.30E-14	3.91E-21	1.07E-14	1.08E-14	8.44E-22
5000 y	1.21E-14	1.13E-13	3.13E-20	2.38E-14	1.84E-14	3.71E-21
10000 y	2.41E-14	1.93E-13	2.05E-19	4.96E-14	4.30E-14	1.09E-20

Notes:

- Radiation dose is the total effective dose equivalent for one year at the elapsed times indicated in the left column. These times are measured from Hanford Site closure.
- Lifetime incremental cancer risk is calculated for a 25-year exposure period using cancer morbidity factors derived for population exposures in Federal Guidance Report Number 13.

Table 3-6. Derivation of Surrogate Wildlife Screening Criteria.

Chemical	Log K_{ow}	Toxicity Data (mg/kg-dy): Mammalian predator (short-tailed shrew)	Toxicity Data (mg/kg-dy): Mammalian Herbivore (meadow vole)	Toxicity Data (mg/kg-dy): Avian Predator (American robin)	K_{plant}	BAF_{worm}	Surrogate Screening Values (mg/kg): Mammalian predator (short-tailed shrew)	Surrogate Screening Values (mg/kg): Mammalian Herbivore (meadow vole)	Surrogate Screening Values (mg/kg): Avian Predator (American robin)	Lowest Surrogate Soil Screening Value (mg/kg)
1,2-Dichloroethane	1.47	61.8[a]	47.2[a]	34.4	5.474	0.7	381.48	27.25	355.20	27.25
Acetone	-0.24	109.9	84	na	53.299	4.7	103.48	5.00	--	5.00
Aluminum	0.329	22.952	17.538	44.5	1.010	4.6	22.08	44.59	86.13	22.08
Aroclor-1254	6.5	0.668	0.511	1.8	0.007	0.9	3.23	50.92	15.21	3.23
Benzene	1.993	313.5	239.5	na	2.729	4.7	295.20	276.04	--	276.04
Bis(2-ethylhexyl)phthalate	7.3	218	166	1.1[a]	0.002	11.8	81.97	19221.74	0.85	0.85
Boron	0.229	206	157	100	1.010	4.6	198.17	481.52	193.56	193.56
Cyanide	-0.6928	141.9[a]	108.4[a]	na	97.373	4.7	133.62	3.53	--	3.53
Dibutyl phthalate	4.5	2,180	1,666	1.1	0.097	4.7	2052.73	43305.27	2.09	2.09
Diethyl phthalate	2.42	5,450[a]	4,165[a]	na	1.546	4.7	5131.83	8415.43	--	5131.83
Fluoride	0.2228	150.7	115.2	32	1.010	4.6[b]	144.97	353.32	61.94	61.94
Methylene chloride	1.25	109.9	84	na	7.337	0.7	678.40	36.22	--	36.22
Nitrate	0.209	3109	2376	na	1.010	4.6[b]	2990.86	7287.23	--	2990.86
Tetrachloroethylene	2.67	8.32	6.36	na	1.109	0.7	51.36	17.81	--	17.81
Thallium	0.229	0.164	0.126	na	1.010	4.6	0.07	0.39	--	0.16
Tin	1.289	41.6	31.8	16.9	1.010	4.6	40.02	97.53	32.71	32.71
Toluene	2.5403	309.2	236.3	na	1.317	4.7	291.15	558.80	--	291.15
Uranium	0.229	7.165	5.475	16[a]	1.010	4.6	6.89	16.79	30.97	6.89
Xylenes (total)	3.0876	3.092	2.363	na	0.636	4.7	2.91	11.35	--	2.91

a. Value is a NOAEL; LOAEL was not available

b. A BAF_{worm} value was not available in the categories listed in Table 749-5 of WAC 173-340-900; the default metals value was considered a sufficiently conservative estimate

Source for Toxicity Data: LOAELs from Table 12 of Sample et al. (1996), unless noted otherwise

Sources for Log K_{ow} values: ORNL (Sample et al. 1996) and Syracuse Research Corporation, LOGKOW demo (http://www.syrres.com/esc/est_kowdemo.htm)
Values for diethylphthalate and di-n-butylphthalate from Ellington and Floyd (1996)

K_{plant} values: Default value from Table 749-5, WAC 173-340-900, for metals (1.01); calculated for organics (K_{plant} = 10^(1.588-(0.578 Log K_{ow}))

BAF_{worm} values: Default values from Table 749-5, WAC 173-340-900

RGAF values: 1.0 (Default value from Table 749-5, WAC 173-340-900)

Surrogate screening value calculations are based on equations in Table 749-4, WAC 173-340-900

K_{plant}= plant uptake coefficient

BAF_{worm}= bioaccumulation factor for worms

Table 3-7a. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m (15 ft) Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Inorganic metal (mg/kg)								
Aluminum	10,100	1.8 [6.0] - 2.1 [7.0]	11,800	No	22	ORNL	No	Less than background
Antimony	ND	~	NA	NA	0.27	EPA	No	Not detected
Arsenic	12.2	2.6 [8.5] - 2.9 [9.5]	6.47	Yes	7	WAC	Yes	Exceeds screening level
Barium	118	1.8 [6.0] - 2.1 [7.0]	132	No	102	WAC	No	Less than background
Beryllium	0.626	1.2 [4.0] - 2.0 [6.5]	1.51	No	21	EPA	No	Less than background
Bismuth	0.766	1.2 [4.0] - 2.0 [6.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Boron	3.4	1.2 [4.0] - 1.5 [5.0]	NA	NA	194	ORNL	No	Less than screening level
Cadmium	28	1.2 [4.0] - 1.5 [5.0]	1	Yes	14	WAC	Yes	Exceeds screening level
Calcium	24,300	1.8 [6.0] - 2.1 [7.0]	17,200	Yes	NA	NA	No	Essential nutrient
Chromium (total)	36.8	1.2 [4.0] - 1.5 [5.0]	18.5	Yes	67	WAC	No	Less than screening level
Chromium VI	8.8	2.3 [7.5] - 2.6 [8.5]	NA	NA	81	EPA	No	Less than screening level
Copper	172	1.2 [4.0] - 1.5 [5.0]	22	Yes	217	WAC	No	Essential nutrient
Iron	26,900	1.5 [5.0] - 1.8 [6.0]	32,600	No	NA	NA	No	Less than background

Table 3-7a. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m (15 ft) Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Lead	390	2.3 [7.5] - 2.6 [8.5]	10.2	Yes	118	WAC	Yes	Exceeds screening level
Magnesium	4,310	1.2 [4.0] - 2.0 [6.5]	7,060	No	NA	NA	No	Less than background
Manganese	454	1.8 [6.0] - 2.1 [7.0]	512	No	1,500	WAC	No	Less than background
Mercury (inorganic)	5.2	1.2 [4.0] - 1.5 [5.0]	0.33	Yes	5.5	WAC	No	Less than screening level
Molybdenum	3.2	1.2 [4.0] - 1.5 [5.0]	NA	NA	7	WAC	No	Essential nutrient
Nickel	27.6	1.2 [4.0] - 1.5 [5.0]	19.1	Yes	980	WAC	No	Less than screening level
Potassium	2,260	1.8 [6.0] - 2.1 [7.0]	2,150	Yes	NA	NA	No	Essential nutrient
Selenium	2.52	2.7 [9.0] - 3.5 [11.5]	NA	NA	0.3	WAC	Yes	Exceeds screening level
Silver	42	1.2 [4.0] - 1.5 [5.0]	0.73	Yes	4.2	EPA	Yes	Exceeds screening level
Sodium	873	1.2 [4.0] - 1.5 [5.0]	690	Yes	NA	NA	No	Essential nutrient
Thallium	0.52	1.8 [6.0] - 2.1 [7.0]	NA	NA	0.16	ORNL	Yes	Exceeds screening level
Tin	ND	~	NA	NA	33	ORNL	No	Not detected
Uranium	5.28	2.3 [7.5] - 2.6 [8.5]	3.21	Yes	6.9	ORNL	No	Less than screening level

Table 3-7a. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m (15 ft) Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Vanadium	104	2.3 [7.5] - 2.6 [8.5]	85.1	Yes	7.8	EPA	Yes	Exceeds screening level
Zinc	224	1.2 [4.0] - 1.5 [5.0]	67.8	Yes	360	WAC	No	Essential nutrient
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3	41.7	1.2 [4.0] - 1.5 [5.0]	9.23	Yes	NA	NA	Yes	Exceeds background
Bromide	ND	~	NA	NA	NA	NA	No	Not detected
Chloride	226	1.2 [4.0] - 1.5 [5.0]	100	Yes	NA	NA	No	Essential nutrient
Cyanide	ND	~	NA	NA	3.5	ORNL	No	Not detected
Fluoride	5.26	2.7 [9.0] - 3.5 [11.5]	2.81	Yes	62	ORNL	No	Less than screening level
Hydrazine	ND	~	NA	NA	NA	NA	No	Not detected
Nitrate (total)	927	1.2 [4.0] - 1.5 [5.0]	52	Yes	2,991	ORNL	No	Less than screening level
Nitrite (total)	ND	~	NA	NA	NA	NA	No	Not detected
Nitrate/nitrite as N[e]	210	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	No	Detected, no background or screening value
Phosphate	ND	~	0.785	No	NA	NA	No	Not detected
Sulfate	2,970	1.2 [4.0] - 1.5 [5.0]	237	Yes	NA	NA	Yes	Exceeds background
Sulfide	ND	~	NA	NA	NA	NA	No	Not detected
Detected Organic Compounds (µg/kg)								
1,2-Dichloroethane	13	1.2 [4.0] - 1.5 [5.0]	NA	NA	27,250	ORNL	No	Less than screening level

Table 3-7a. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m (15 ft) Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Acetone	30	2.3 [7.5] - 2.6 [8.5]	NA	NA	5,001	ORNL	No	Less than screening level
Aroclor-1254	9,400	1.2 [4.0] - 1.5 [5.0]	NA	NA	3,230	ORNL	Yes	Exceeds screening level
Benzo(a)anthracene	180	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Benzo(a)pyrene	160	1.2 [4.0] - 1.5 [5.0]	NA	NA	12,000	WAC	No	Less than screening level
Benzo(b)fluoranthene	240	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Bis(2-ethylhexyl) phthalate	6,200	1.2 [4.0] - 1.5 [5.0]	NA	NA	852	ORNL	Yes	Exceeds screening level
Butyl benzyl phthalate	290	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Chrysene	210	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Dibutyl phthalate	2,741	1.2 [4.0] - 1.5 [5.0]	NA	NA	2,086	ORNL	Yes	Exceeds screening level
Diethyl phthalate	330	2.7 [9.0] - 3.5 [11.5]	NA	NA	5,000,000	ORNL	No	Less than screening level
Fluoranthene	370	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Kerosene range TPH	440,000	1.2 [4.0] - 2.0 [6.5]	NA	NA	5,000,000	WAC	No	Less than screening level
Mesityl oxide	390	2.7 [9.0] - 3.5 [11.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Methylene chloride	78	1.2 [4.0] - 1.5 [5.0]	NA	NA	36,220	ORNL	No	Less than screening level
Motor oil TPH	760,000	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value

Table 3-7a. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-A-29 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m (15 ft) Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
N-Butylbenzenesulfonamide	4,400	2.7 [9.0] - 3.5 [11.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Phenanthrene	370	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Pyrene	350	1.2 [4.0] - 1.5 [5.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Tetrachloroethylene	6	1.2 [4.0] - 1.5 [5.0]	NA	NA	17,811	ORNL	No	Less than screening level
Tributyl phosphate	543	1.2 [4.0] - 2.0 [6.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.
[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).
[c]A heirarchical approach was used for selecting soil indicator values for terrestrial (i.e., when a screening value was unavailable from the primary source, secondary or tertiary sources were consulted). Screening value sources may be any of the following:

* WAC = Washington Administrative Code; soil indicator values appear in Table 749-3 of the MTCA Cleanup Regulation (WAC 173-340-900)
* EPA = EPA Eco-SSLs (ecological soil screening levels); available online: http://www.epa.gov/ecotox/ecossl/
* ORNL = Oak Ridge National Laboratory toxicological benchmarks (Sample et al. 1996)

[d]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.
[e]Nitrate/Nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.
bgs = below ground surface
COEC = Contaminant of ecological concern.
EPA = U.S. Environmental Protection Agency.
NA = Not applicable/not available.
ND = Not detected.
TPH = Total petroleum hydrocarbons.
Shading indicates that the chemical was retained as a contaminant of ecological concern.
Significant figures were considered when comapring values, but the most precise values are shown in the table.

Table 3-7b. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Inorganic metal (mg/kg)								
Aluminum	7,090	3.2 [10.5] - 4.0 [13.0]	11,800	No	22	ORNL	No	Less than background
Antimony	5	1.2 [4.0] - 2.0 [6.5]	NA	NA	0.27	EPA	Yes	Exceeds screening level
Arsenic	5.1	4.6 [15.0] - 5.2 [17.0]	6.47	No	7	WAC	No	Less than background
Barium	96.9	2.3 [7.5] - 2.6 [8.5]	132	No	102	WAC	No	Less than background
Beryllium	0.713	3.8 [12.5] - 4.4 [14.5]	1.51	No	21	EPA	No	Less than background
Bismuth	37.1	2.4 [8.0] - 3.2 [10.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Boron	6.3	2.4 [8.0] - 3.2 [10.5]	NA	NA	194	ORNL	No	Less than screening level
Cadmium	0.27	1.5 [5.0] - 1.8 [6.0]	1	No	14	WAC	No	Less than background
Calcium	8,760	2.4 [8.0] - 3.2 [10.5]	17,200	No	NA	NA	No	Less than background
Chromium (total)	21.9	3.8 [12.5] - 4.4 [14.5]	18.5	Yes	67	WAC	No	Less than screening level
Chromium VI	0.45	2.9 [9.5] - 3.2 [10.5]	NA	NA	81	EPA	No	Less than screening level
Cobalt	11.4	2.4 [8.0] - 3.2 [10.5]	15.7	No	120	EPA	No	Less than background

Table 3-7b. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Copper	30.6	3.7 [12.0] - 4.0 [13.0]	22	Yes	217	WAC	No	Essential nutrient
Iron	28,400	1.8 [6.0] - 2.1 [7.0]	32,600	No	NA	NA	No	Less than background
Lead	7.5	2.4 [8.0] - 3.2 [10.5]	10.2	No	118	WAC	No	Less than background
Magnesium	4,930	1.8 [6.0] - 2.1 [7.0]	7,060	No	NA	NA	No	Less than background
Manganese	410	1.8 [6.0] - 2.1 [7.0]	512	No	1,500	WAC	No	Less than background
Mercury (inorganic)	0.15	4.0 [13.0] - 4.7 [15.5]	0.33	No	5.5	WAC	No	Less than background
Molybdenum	0.55	1.5 [5.0] - 1.8 [6.0]	NA	NA	7	WAC	No	Essential nutrient
Nickel	15	3.8 [12.5] - 4.4 [14.5]	19.1	No	980	WAC	No	Less than background
Potassium	1,740	1.5 [5.0] - 1.8 [6.0]	2,150	No	NA	NA	No	Less than background
Selenium	0.75	2.3 [7.5] - 2.6 [8.5]	NA	NA	0.3	WAC	Yes	Exceeds screening level
Silver	0.86	2.4 [8.0] - 3.2 [10.5]	0.73	Yes	4.2	EPA	No	Less than screening level
Sodium	671	3.2 [10.5] - 4.0 [13.0]	690	No	NA	NA	No	Less than background

Table 3-7b. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Thallium	0.53	1.8 [6.0] - 2.1 [7.0]	NA	NA	0.16	ORNL	Yes	Exceeds screening level
Tin	ND	~	NA	NA	33	ORNL	No	Not detected
Uranium	2.38	4.0 [13.0] - 4.7 [15.5]	3.21	No	6.9	ORNL	No	Less than background
Vanadium[d]	86.9	2.3 [7.5] - 2.6 [8.5]	85.1	No	7.8	EPA	No	Less than background
Zinc	80.8	3.7 [12.0] - 4.0 [13.0]	67.8	Yes	360	WAC	No	Essential nutrient
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3[d]	9.99	4.6 [15.0] - 5.2 [17.0]	9.23	No	NA	NA	No	Less than background
Chloride	17.9	1.5 [5.0] - 1.8 [6.0]	100	No	NA	NA	No	Less than background
Cyanide	ND	~	NA	NA	3.5	ORNL	No	Not detected
Fluoride	0.76	2.3 [7.5] - 2.6 [8.5]	2.81	No	62	ORNL	No	Less than background
Hydrazine	ND	~	NA	NA	NA	NA	No	Not detected
Nitrate (total)	833	1.5 [5.0] - 1.8 [6.0]	52	Yes	2,991	ORNL	No	Less than screening level
Nitrite (total)	1.25	1.2 [4.0] - 2.0 [6.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value

Table 3-7b. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Nitrate/nitrite as N[f]	230	1.5 [5.0] - 1.8 [6.0]	NA	NA	NA	NA	No	Detected, no background or screening value
Phosphate	6.4	2.1 [7.0] - 2.4 [8.0]	0.785	Yes	NA	NA	Yes	Exceeds background
Sulfate	76.2	1.5 [5.0] - 1.8 [6.0]	237	No	NA	NA	No	Less than background
Sulfide	43.8	3.4 [11.0] - 3.7 [12.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Detected Organic Compounds (μg/kg)								
2-Ethylhexanol	6	4.0 [13.0] - 4.7 [15.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Acetone	66	1.5 [5.0] - 1.8 [6.0]	NA	NA	5,001	ORNL	No	Less than screening level
Aroclor-1254	77	3.0 [10.0] - 4.0 [13.0]	NA	NA	3,230	ORNL	No	Less than screening level
Aroclor-1260[e]	9,200	2.4 [8.0] - 3.2 [10.5]	NA	NA	650	WAC	Yes	Exceeds screening level
Benzene	8	1.5 [5.0] - 1.8 [6.0]	NA	NA	276,000	ORNL	No	Less than screening level
Bis(2-ethylhexyl) phthalate	21	2.4 [8.0] - 2.9 [9.5]	NA	NA	852	ORNL	No	Less than screening level
Di-n-octyl phthalate	52	4.0 [13.0] - 4.7 [15.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Methylene chloride	27	2.9 [9.5] - 3.2 [10.5]	NA	NA	36,220	ORNL	No	Less than screening level

Table 3-7b. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-B-63 Trench. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Toluene	3	2.1 [7.0] - 2.4 [8.0]	NA	NA	291,000	ORNL	No	Less than screening level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).

[c]A heirarchical approach was used for selecting soil indicator values for terrestrial (i.e., when a screening value was unavailable from the primary source, secondary or tertiary sources were consulted). Screening value sources may be any of the following:

* WAC = Washington Administrative Code; soil indicator values appear in Table 749-3 of the MTCA Cleanup Regulation (WAC 173-340-900)
* EPA = EPA Eco-SSLs (ecological soil screening levels); available online: http://www.epa.gov/ecotox/ecossl/
* ORNL = Oak Ridge National Laboratory toxicological benchmarks (Sample et al. 1996).

[d]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[e]Due to a lack of wildlife toxicological data for Aroclor-1260, the screening value for total PCB mixtures was used for this constituent.

[f]Nitrate/nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criteria.

bgs = below ground surface

COEC = Contaminant of ecological concern.

EPA = U.S. Environmental Protection Agency.

NA = Not applicable/not available.

ND = Not detected.

TPH = Total petroleum hydrocarbons.

Shading indicates that the chemical was retained as a contaminant of ecological concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-7c. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Inorganic metal (mg/kg)								
Aluminum	10,800	0.0 [0.0] - 0.5 [1.5]	11,800	No	22	ORNL	No	Less than background
Arsenic	5.5	2.6 [8.5] - 2.9 [9.5]	6.47	No	7	WAC	No	Less than background
Barium	120	0.9 [3.0] - 1.2 [4.0]	132	No	102	WAC	No	Less than background
Beryllium	0.5	2.0 [6.5] - 2.7 [9.0]	1.51	No	21	EPA	No	Less than background
Bismuth	2	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Boron	1.5	0.0 [0.0] - 0.5 [1.5]; 1.8 [6.0] - 2.1 [7.0]	NA	NA	194	ORNL	No	Less than screening level
Cadmium	0.48	0.0 [0.0] - 0.5 [1.5]	1	No	14	WAC	No	Less than background
Calcium	3,880	0.9 [3.0] - 1.2 [4.0]	17,200	No	NA	NA	No	Less than background
Chromium (total)	815	0.0 [0.0] - 0.5 [1.5]	18.5	Yes	67	WAC	Yes	Exceeds screening level
Chromium VI	14.1	0.5 [1.5] - 0.9 [3.0]	NA	NA	81	EPA	No	Less than screening level
Copper	244	0.0 [0.0] - 0.5 [1.5]	22	Yes	217	WAC	Yes	Exceeds screening level
Iron	28,800	0.0 [0.0] - 0.5 [1.5]	32,600	No	NA	NA	No	Less than background
Lead	30	0.0 [0.0] - 0.5 [1.5]	10.2	Yes	118	WAC	No	Less than screening level

Table 3-7c. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Magnesium	4,370	0.9 [3.0] - 1.2 [4.0]	7,060	No	NA	NA	No	Less than background
Manganese	451	0.9 [3.0] - 1.2 [4.0]	512	No	1,500	WAC	No	Less than background
Mercury (inorganic)	4.3	0.0 [0.0] - 0.5 [1.5]	0.33	Yes	5.5	WAC	No	Less than screening level
Molybdenum	0.88	0.0 [0.0] - 0.5 [1.5]	NA	NA	7	WAC	No	Essential nutrient
Nickel	20.3	0.0 [0.0] - 0.5 [1.5]	19.1	Yes	980	WAC	No	Less than screening level
Potassium	856	0.9 [3.0] - 1.2 [4.0]	2,150	No	NA	NA	No	Less than background
Selenium	0.44	2.6 [8.5] - 2.9 [9.5]	NA	NA	0.3	WAC	Yes	Exceeds screening level
Silver	30.4	0.0 [0.0] - 0.5 [1.5]	0.73	Yes	4.2	EPA	Yes	Exceeds screening level
Sodium	176	0.0 [0.0] - 0.5 [1.5]	690	No	NA	NA	No	Less than background
Thallium	0.99	0.0 [0.0] - 0.5 [1.5]	NA	NA	0.16	ORNL	Yes	Exceeds screening level
Uranium	1.49	2.6 [8.5] - 2.9 [9.5]	3.21	No	6.9	ORNL	No	Less than background
Vanadium[d]	87.5	2.6 [8.5] - 2.9 [9.5]	85.1	No	7.8	EPA	No	Less than background
Zinc	506	0.0 [0.0] - 0.5 [1.5]	67.8	Yes	360	WAC	Yes	Exceeds screening level
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3	ND	~	9.23	No	NA	NA	No	Not detected
Chloride	11.5	2.4 [8.0] - 2.7 [9.0]	100	No	NA	NA	No	Less than background

Table 3-7c. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Cyanide	ND	~	NA	NA	3.5	ORNL	No	Not detected
Fluoride	0.7	2.6 [8.5] - 2.9 [9.5]	2.81	No	62	ORNL	No	Less than background
Nitrate (total)	80.6	0.0 [0.0] - 0.5 [1.5]	52	Yes	2,991	ORNL	No	Less than screening level
Nitrite (total)	1.15	2.6 [8.5] - 2.9 [9.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Nitrate/nitrite as N[e]	10.6	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	No	Detected, no background or screening value
Phosphate[d]	1.5	0.9 [3.0] - 1.2 [4.0]	0.785	No	NA	NA	No	Less than background
Sulfate	199	0.0 [0.0] - 0.5 [1.5]	237	No	NA	NA	No	Less than background
Sulfide	ND	~	NA	NA	NA	NA	No	Not detected
Detected Organic Compounds (µg/kg)								
Acenaphthene	61	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	WAC	Yes	Detected, no background or screening value
Acetone	9	4.1 [13.5] - 4.4 [14.5]	NA	NA	5,001	ORNL	No	Less than screening level
Anthracene	150	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Aroclor-1254	3,700	0.0 [0.0] - 0.5 [1.5]	NA	NA	3,230	ORNL	Yes	Exceeds screening level
Benzo(a)anthracene	550	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Benzo(a)pyrene	600	0.0 [0.0] - 0.5 [1.5]	NA	NA	12,000	WAC	No	Less than screening level
Benzo(b)fluoranthene	530	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value

Table 3-7c. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Benzo(g,h,i)perylene	660	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Benzo(k)fluoranthene	450	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Bis(2-ethylhexyl) phthalate	580	0.0 [0.0] - 0.5 [1.5]	NA	NA	852	ORNL	No	Less than screening level
Butyl benzyl phthalate	580	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Carbazole	97	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Chrysene	680	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Dibenzo(a,h)anthracene	110	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Dibutyl phthalate	2,300	0.0 [0.0] - 0.5 [1.5]	NA	NA	2,086	ORNL	Yes	Exceeds screening level
Diesel Range TPH	31,000	0.0 [0.0] - 0.5 [1.5]	NA	NA	6,000,000	WAC	No	Less than screening level
Fluoranthene	1,500	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Fluorene	59	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Indeno(1,2,3-cd)pyrene	400	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Methylene chloride	10	0.5 [1.5] - 0.9 [3.0]; 2.6 [8.5] - 2.9 [9.5]	NA	NA	36,220	ORNL	No	Less than screening level

Table 3-7c. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Ditch. (5 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Phenanthrene	930	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Pyrene	1,600	0.0 [0.0] - 0.5 [1.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).

[c]A heirarchical approach was used for selecting soil indicator values for terrestrial (i.e., when a screening value was unavailable from the primary source, secondary or tertiary sources were consulted). Screening value sources may be any of the following:

* WAC = Washington Administrative Code; soil indicator values appear in Table 749-3 of the MTCA Cleanup Regulation (WAC 173-340-900)
* EPA = EPA Eco-SSLs (ecological soil screening levels); available online: http://www.epa.gov/ecotox/ecossl/
* ORNL = Oak Ridge National Laboratory toxicological benchmarks (Sample et al. 1996).

[d]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[e]Nitrate/nitrite as N was not evaluated becasye the total nitrate and total nitrite concentrations have their own criteria.

bgs = below ground surface

COEC = Contaminant of ecological concern.

EPA = U.S. Environmental Protection Agency.

NA = Not applicable/not available.

ND = Not detected.

TPH = Total petroleum hydrocarbons.

Shading indicates that the chemical was retained as a contaminant of ecological concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-7d. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (3 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Inorganic metal (mg/kg)								
Aluminum	5,870	1.8 [6.0] - 2.1 [7.0]	11,800	No	22	ORNL	No	Less than background
Arsenic	5.6	2.0 [6.5] - 2.3 [7.5]	6.47	No	7	WAC	No	Less than background
Barium	103	4.3 [14.0] - 4.6 [15.0]	132	No	102	WAC	No	Less than background
Beryllium	0.42	1.2 [4.0] - 1.5 [5.0]	1.51	No	21	EPA	No	Less than background
Bismuth	ND	~	NA	NA	NA	NA	No	Not detected
Boron	1	1.8 [6.0] - 2.1 [7.0]	NA	NA	194	ORNL	No	Less than screening level
Cadmium	0.2	2.7 [9.0] - 3.0 [10.0]	1	No	14	WAC	No	Less than background
Calcium	11,100	1.2 [4.0] - 1.5 [5.0]	17,200	No	NA	NA	No	Less than background
Chromium (total)	26.2	2.7 [9.0] - 3.0 [10.0]; 3.4 [11.0] - 3.7 [12.0]	18.5	Yes	67	WAC	No	Less than screening level
Chromium VI	2.7	2.1 [7.0] - 2.4 [8.0]	NA	NA	81	EPA	No	Less than screening level
Copper	17.7	2.0 [6.5] - 2.3 [7.5]; 2.9 [9.5] - 3.2 [10.5]	22	No	217	WAC	No	Less than background
Iron	25,100	1.2 [4.0] - 1.5 [5.0]; 1.8 [6.0] - 2.1 [7.0]	32,600	No	NA	NA	No	Less than background
Lead	5.4	1.8 [6.0] - 2.1 [7.0]	10.2	No	118	WAC	No	Less than background
Magnesium	4,780	1.2 [4.0] - 1.5 [5.0]	7,060	No	NA	NA	No	Less than background
Manganese	392	1.8 [6.0] - 2.1 [7.0]	512	No	1,500	WAC	No	Less than background
Mercury (inorganic)	0.43	3.5 [11.5] - 3.8 [12.5]	0.33	Yes	5.5	WAC	No	Less than screening level
Molybdenum	0.29	2.0 [6.5] - 2.3 [7.5]	NA	NA	7	WAC	No	Less than screening level
Nickel	12	2.0 [6.5] - 2.3 [7.5]	19.1	No	980	WAC	No	Less than background
Potassium	1,230	1.8 [6.0] - 2.1 [7.0]	2,150	No	NA	NA	No	Less than background
Selenium	0.46	2.7 [9.0] - 3.0 [10.0]	NA	NA	0.3	WAC	Yes	Exceeds screening level
Silver	8.3	2.7 [9.0] - 3.0 [10.0]	0.73	Yes	4.2	EPA	Yes	Exceeds screening level

Table 3-7d. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (3 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Sodium	193	2.0 [6.5] - 2.3 [7.5]	690	No	NA	NA	No	Less than background
Thallium	0.62	1.2 [4.0] - 1.5 [5.0]	NA	NA	0.16	ORNL	Yes	Exceeds screening level
Uranium	2.01	2.9 [9.5] - 3.2 [10.5]	3.21	No	6.9	ORNL	No	Less than background
Vanadium	81.7	2.9 [9.5] - 3.2 [10.5]	85.1	No	7.8	EPA	No	Less than background
Zinc	59.7	2.9 [9.5] - 3.2 [10.5]	67.8	No	360	WAC	No	Less than background
General Inorganic Compounds (mg/kg)								
Ammonia as NH_3	ND	~	9.23	No	NA	NA	No	Not detected
Chloride	3.1	2.9 [9.5] - 3.2 [10.5]	100	No	NA	NA	No	Less than background
Cyanide	0.2	2.9 [9.5] - 3.2 [10.5]	NA	NA	3.5	ORNL	No	Less than screening level
Fluoride	1.1	2.9 [9.5] - 3.2 [10.5]	2.81	No	62	ORNL	No	Less than background
Nitrate (total)	45	2.0 [6.5] - 2.3 [7.5]	52	No	2,991	ORNL	No	Less than background
Nitrite (total)	1.58	2.9 [9.5] - 3.2 [10.5]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Nitrate/nitrite as N[d]	14.9	2.0 [6.5] - 2.3 [7.5]	NA	NA	NA	NA	No	Detected, no background or screening value
Phosphate[e]	3.8	3.5 [11.5] - 3.8 [12.5]	0.785	No	NA	NA	No	Less than background
Sulfate	11.5	2.0 [6.5] - 2.3 [7.5]	237	No	NA	NA	No	Less than background
Sulfide	59	3.4 [11.0] - 3.7 [12.0]	NA	NA	NA	NA	Yes	Detected, no background or screening value
Detected Organic Compounds (µg/kg)								
Acetone	26	2.6 [8.5] - 2.9 [9.5]	NA	NA	5,001	ORNL	No	Less than screening level

Table 3-7d. Ecological Screening Values and Contaminants of Ecological Concern for Chemicals in Shallow-Zone Soil (0 to 4.6 m [0 to 15 ft]) at the 216-S-10 Pond. (3 sheets)

Constituent[a]	Top 4.6 m [15 ft] Maximum Concentration[b]	Depth of Maximum Detected from 0 to 4.6 m [ft] bgs	90th Percentile Background Concentration	Does Maximum Concentration Exceed Background?	Soil Indicator Value (Terrestrial Wildlife)	Soil Indicator Value Source[c]	COEC?	Justification
Bis(2-ethylhexyl) phthalate	140	1.2 [4.0] - 1.5 [5.0]	NA	NA	852	ORNL	No	Less than screening level
Methylene chloride	15	2.9 [9.5] - 3.2 [10.5]	NA	NA	36,220	ORNL	No	Less than screening level
Toluene	4.2	2.9 [9.5] - 3.2 [10.5]	NA	NA	291,000	ORNL	No	Less than screening level
Xylenes (total)	1.388	1.8 [6.0] - 2.1 [7.0]	NA	NA	2,900	ORNL	No	Less than screening level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Shallow-zone maximum concentration determination included all samples down to and including the 4.6 m [15 ft] depth. A sample was included if the 4.6 m [15 ft] depth was the highest point of the sample depth range (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample).

[c]A heirarchical approach was used for selecting soil indicator values for terrestrial (i.e., when a screening value was unavailable from the primary source, secondary or tertiary sources were consulted). Screening value sources may be any of the following:

* WAC = Washington Administrative Code; soil indicator values appear in Table 749-3 of the MTCA Cleanup Regulation (WAC 173-340-900)
* EPA = EPA Eco-SSLs (ecological soil screening levels); available online: http://www.epa.gov/ecotox/ecossl/
* ORNL = Oak Ridge National Laboratory toxicological benchmarks (Sample et al. 1996).

[d]Nitrate/nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criteria.

[e]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

bgs = below ground surface

COEC = Contaminant of ecological concern.

EPA = U.S. Environmental Protection Agency.

NA = Not applicable/not available.

ND = Not detected.

TPH = Total petroleum hydrocarbons.

Shading indicates that the chemical was retained as a contaminant of ecological concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-8. Ecological Biota Concentration Guideline and Contaminants of Ecological Concern for Radionuclides in Shallow-Zone Soils (0 to 4.6 m [0 to 15 ft]) Across all Waste Sites. (7 sheets)

Radionuclides	Exposure Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	COEC?	Justification
216-A-29 Ditch						
Actinium-228	0.429	1.32	NA	NA	No	Less than background
Americium-241	145	NA	NA	4,000	No	Less than screening level
Antimony-125	1.67	NA	NA	3,000	No	Less than screening level
Barium-133	ND	NA	NA	NA	No	Not detected
Bismuth-212	0.282	NA	NA	NA	No	Detected, no background or screening value
Bismuth-214	0.392	NA	NA	NA	No	Detected, no background or screening value
Carbon-14	ND	NA	NA	NA	No	Not detected
Cerium-144	ND	NA	NA	1,000	No	Not detected
Cesium-134	ND	NA	NA	NA	No	Not detected
Cesium-137	98.4	1.05	Yes	20	Yes	Exceeds screening level
Cobalt-60	ND	0.00842	No	700	No	Not detected
Curium-242	ND	NA	NA	NA	No	Not detected
Curium-243/244	ND	NA	NA	NA	No	Not detected
Europium-152	ND	NA	NA	NA	No	Not detected
Europium-154	ND	0.0334	No	1,000	No	Not detected
Europium-155	0.05	0.0539	No	20,000	No	Less than background
Lead-212	0.445	NA	NA	NA	Yes	Detected, no background or screening value
Lead-214	0.432	NA	NA	NA	Yes	Detected, no background or screening value
Neptunium-237	0.124	NA	NA	NA	Yes	Detected, no background or screening value
Nickel-63	ND	NA	NA	NA	No	Not detected
Niobium-94	ND	NA	NA	NA	No	Not detected
Plutonium-238	15.7	0.00378	Yes	NA	Yes	Exceeds background
Plutonium-239/240	667	0.0248	Yes	6,000	No	Less than screening level

Table 3-8. Ecological Biota Concentration Guideline and Contaminants of Ecological Concern for Radionuclides in Shallow-Zone Soils (0 to 4.6 m [0 to 15 ft]) Across all Waste Sites. (7 sheets)

Radionuclides	Exposure Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	COEC?	Justification
Potassium-40	16	16.6	No	NA	No	Less than background
Radium-226[c,e]	0.895	0.815	Yes	50	No	Less than screening level
Radium-228[c]	1.11	1.32	NA	40	No	Less than screening level
Ruthenium-103	ND	NA	NA	NA	No	Not detected
Ruthenium-106	ND	NA	NA	NA	No	Not detected
Sodium-22	ND	NA	NA	NA	No	Not detected
Strontium-90[a]	0.779	0.178	Yes	20	No	Less than screening level
Technetium-99	ND	NA	NA	4,000	No	Not detected
Thallium-208	0.136	NA	NA	NA	No	Detected, no background or screening value
Thorium-228[c]	1.14	1.32	NA	NA	No	Less than background
Thorium-230[c]	1.49	1.1	Yes	NA	Yes	Exceeds background
Thorium-232[c]	1.22	1.32	No	2,000	No	Less than background
Thorium-234	ND	NA	NA	NA	No	Not detected
Tin-113	ND	NA	NA	NA	No	Not detected
Tin-126	ND	NA	NA	NA	No	Not detected
Tritium	ND	NA	NA	NA	No	Not detected
Uranium-233/234[b]	2.31	1.1	Yes	5,000	No	Less than screening level
Uranium-234	0.964	1.1	No	5,000	No	Less than background
Uranium-235	0.439	0.109	Yes	3,000	No	Less than screening level
Uranium-238	1.81	1.06	Yes	2,000	No	Less than screening level
Zinc-65	ND	NA	NA	400	No	Not detected
216-B-63 Trench						
Actinium-228	NLA	1.32	NA	NA	No	Not detected
Americium-241	0.589	NA	NA	4,000	No	Less than screening level
Antimony-125	ND	NA	NA	3,000	No	Not detected

Table 3-8. Ecological Biota Concentration Guideline and Contaminants of Ecological Concern for Radionuclides in Shallow-Zone Soils (0 to 4.6 m [0 to 15 ft]) Across all Waste Sites. (7 sheets)

Radionuclides	Exposure Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	COEC?	Justification
Barium-133	ND	NA	NA	NA	No	Not detected
Bismuth-212	NLA	NA	NA	NA	No	Not detected
Bismuth-214	NLA	NA	NA	NA	No	Not detected
Carbon-14	ND	NA	NA	NA	No	Not detected
Cerium-144	NLA	NA	NA	1,000	No	Not detected
Cesium-134	ND	NA	NA	NA	No	Not detected
Cesium-137	100	1.05	Yes	20	Yes	Exceeds screening level
Cobalt-60	ND	0.00842	No	700	No	Not detected
Curium-242	ND	NA	NA	NA	No	Not detected
Curium-243/244	ND	NA	NA	NA	No	Not detected
Curium-244	ND	NA	NA	NA	No	Not detected
Europium-152	ND	NA	NA	NA	No	Not detected
Europium-154	1.29	0.0334	Yes	1,000	No	Less than screening level
Europium-155	ND	0.0539	No	20,000	No	Not detected
Iodine-129	ND	NA	NA	6,000	No	Not detected
Lead-212	NLA	NA	NA	NA	No	Not detected
Lead-214	NLA	NA	NA	NA	No	Not detected
Neptunium-237	0.054	NA	NA	NA	Yes	Detected, no background or screening value
Nickel-63	NLA	NA	NA	NA	No	Not detected
Niobium-94	NLA	NA	NA	NA	No	Not detected
Plutonium-238	ND	0.00378	No	NA	No	Not detected
Plutonium-239/240	4.97	0.0248	Yes	6,000	No	Less than screening level
Plutonium-241	ND	NA	NA	NA	No	Not detected
Potassium-40	15	16.6	No	NA	No	Less than background
Radium-224	0.91	NA	NA	NA	No	Detected, no background or screening value

Table 3-8. Ecological Biota Concentration Guideline and Contaminants of Ecological Concern for Radionuclides in Shallow-Zone Soils (0 to 4.6 m [0 to 15 ft]) Across all Waste Sites. (7 sheets)

Radionuclides	Exposure Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	COEC?	Justification
Radium-226[c]	0.762	0.815	No	50	No	Less than background
Radium-228[c]	0.917	1.32	NA	40	No	Less than background
Ruthenium-103	NLA	NA	NA	NA	No	Not detected
Ruthenium-106	NLA	NA	NA	NA	No	Not detected
Selenium-79	ND	NA	NA	NA	No	Not detected
Sodium-22	ND	NA	NA	NA	No	Not detected
Strontium-90[a]	4710	0.178	Yes	20	Yes	Exceeds screening level
Technetium-99[d]	ND	NA	NA	4,000	No	Not detected
Thallium-208	NLA	NA	NA	NA	No	Not detected
Thorium-228[c]	0.975	1.32	NA	NA	Yes	Less than background
Thorium-230[c]	2.67	1.1	Yes	NA	Yes	Exceeds background
Thorium-232[c]	0.888	1.32	No	2,000	No	Less than background
Thorium-234	NLA	NA	NA	NA	No	Not detected
Tin-113[f]	NLA	NA	NA	NA	No	Not detected
Tin-126	ND	NA	NA	NA	No	Not detected
Tritium	NLA	NA	NA	200,000	No	Not detected
Uranium-233/234[b]	0.36	1.1	No	5,000	No	Less than background
Uranium-234	0.748	1.1	No	5,000	No	Less than background
Uranium-235	ND	0.109	No	3,000	No	Not detected
Uranium-238	0.93	1.06	No	2,000	No	Less than background
Zinc-65	NLA	NA	NA	400	No	Not detected
216-S-10 Ditch						
Actinium-228	NLA	1.32	NA	NA	No	Not detected
Americium-241	1.84	NA	NA	4,000	No	Less than screening level
Antimony-125	ND	NA	NA	3,000	No	Not detected
Barium-133	ND	NA	NA	NA	No	Not detected
Bismuth-212	NLA	NA	NA	NA	No	Not detected

Table 3-8. Ecological Biota Concentration Guideline and Contaminants of Ecological Concern for Radionuclides in Shallow-Zone Soils (0 to 4.6 m [0 to 15 ft]) Across all Waste Sites. (7 sheets)

Radionuclides	Exposure Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	COEC?	Justification
Bismuth-214	NLA	NA	NA	NA	No	Not detected
Carbon-14	ND	NA	NA	NA	No	Not detected
Cerium-144	NLA	NA	NA	1,000	No	Not detected
Cesium-134	ND	NA	NA	NA	No	Not detected
Cesium-137	9.13	1.05	Yes	20	No	Less than screening level
Cobalt-60	ND	0.00842	No	700	No	Not detected
Curium-242	ND	NA	NA	NA	No	Not detected
Curium-243/244	ND	NA	NA	NA	No	Not detected
Europium-152	ND	NA	NA	NA	No	Not detected
Europium-154	ND	0.0334	No	1,000	No	Not detected
Europium-155	ND	0.0539	No	20,000	No	Not detected
Lead-212	NLA	NA	NA	NA	No	Not detected
Lead-214	NLA	NA	NA	NA	No	Not detected
Neptunium-237	ND	NA	NA	NA	No	Not detected
Nickel-63	NLA	NA	NA	NA	No	Not detected
Niobium-94	NLA	NA	NA	NA	No	Not detected
Plutonium-238	ND	0.00378	No	NA	No	Not detected
Plutonium-239/240	5.33	0.0248	Yes	6,000	No	Less than screening level
Potassium-40	13.3	16.6	No	NA	No	Less than background
Radium-226[c]	0.603	0.815	No	50	No	Less than background
Radium-228[c]	0.939	1.32	NA	40	No	Less than background
Ruthenium-103	NLA	NA	NA	NA	No	Not detected
Ruthenium-106	NLA	NA	NA	NA	No	Not detected
Sodium-22	ND	NA	NA	NA	No	Not detected
Strontium-90[a]	0.462	0.178	Yes	20	No	Less than screening level
Technetium-99	NLA	NA	NA	400	No	Not detected

Table 3-8. Ecological Biota Concentration Guideline and Contaminants of Ecological Concern for Radionuclides in Shallow-Zone Soils (0 to 4.6 m [0 to 15 ft]) Across all Waste Sites. (7 sheets)

Radionuclides	Exposure Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	COEC?	Justification
Thallium-208	NLA	NA	NA	NA	No	Not detected
Thorium-228[c]	0.903	1.32	NA	NA	No	Less than background
Thorium-230[c]	1.34	1.1	Yes	NA	Yes	Exceeds background
Thorium-232[c]	0.939	1.32	No	2,000	No	Less than background
Thorium-234	NLA	NA	NA	NA	No	Not detected
Tin-113	NLA	NA	NA	NA	No	Not detected
Tin-126	ND	NA	NA	NA	No	Not detected
Tritium	NLA	NA	NA	200,000	No	Not detected
Uranium-234	0.524	1.1	No	5,000	No	Less than background
Uranium-235	ND	0.109	No	3,000	No	Not detected
Uranium-238	0.536	1.06	No	2,000	No	Less than background
Zinc-65[f]	NLA	NA	NA	400	No	Not detected
216-S-10 Pond						
Americium-241	0.395	NA	NA	4,000	No	Less than screening level
Antimony-125	ND	NA	NA	3,000	No	Not detected
Barium-133	ND	NA	NA	NA	No	Not detected
Carbon-14	12.2	NA	NA	NA	Yes	Detected, no background or screening value
Cesium-134	ND	NA	NA	NA	No	Not detected
Cesium-137	1.77	1.05	Yes	20	No	Less than screening level
Cobalt-60	ND	0.00842	No	700	No	Not detected
Curium-242	ND	NA	NA	NA	No	Not detected
Curium-243/244	ND	NA	NA	NA	No	Not detected
Europium-152	ND	NA	NA	NA	No	Not detected
Europium-154	ND	0.0334	No	1,000	No	Not detected
Europium-155	ND	0.0539	No	20,000	No	Not detected
Neptunium-237	ND	NA	NA	NA	No	Not detected

Table 3-8. Ecological Biota Concentration Guideline and Contaminants of Ecological Concern for Radionuclides in Shallow-Zone Soils (0 to 4.6 m [0 to 15 ft]) Across all Waste Sites. (7 sheets)

Radionuclides	Exposure Point Concentration (pCi/g)	90th Percentile Background Concentration (pCi/g)	Exceeds Background?	DOE Biota Concentration Guideline (pCi/g)	COEC?	Justification
Nickel-63	NLA	NA	NA	NA	No	Not detected
Plutonium-238	ND	0.00378	No	NA	No	Not detected
Plutonium-239/240	2.33	0.0248	Yes	6,000	No	Less than screening level
Potassium-40	12.8	16.6	No	NA	No	Less than background
Radium-226[c]	0.546	0.815	No	50	No	Less than background
Radium-228[c]	0.878	1.32	NA	40	No	Less than background
Sodium-22	ND	NA	NA	NA	No	Not detected
Strontium-90[a]	1.26	0.178	Yes	20	No	Less than screening level
Technetium-99	NLA	NA	NA	400	No	Not detected
Thorium-228[c,e]	1.45	1.32	NA	NA	No	Less than background
Thorium-230[c]	1.59	1.1	Yes	NA	Yes	Exceeds background
Thorium-232[c]	0.878	1.32	No	2,000	No	Less than background
Tin-126	ND	NA	NA	NA	No	Not detected
Tritium	NLA	NA	NA	200,000	No	Not detected
Uranium-233/234[b]	NLA	1.1	No	5,000	No	Not detected
Uranium-234	0.563	1.1	No	5,000	No	Less than background
Uranium-235	ND	0.109	No	3,000	No	Not detected
Uranium-238	0.568	1.06	No	2,000	No	Less than background

[a]Analyzed as total beta radiostrontium.
[b]Uranium-233/234 evaluated as uranium-234.
[c]Value based on assumption of secular equilibrium with the parent nuclide.
[d]Actual concentration may reside between 0.04 and 0.4 based on QC data.
[e]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.NA = not available.

ND = not detected.
NLA = no laboratory analysis conducted.
Shading indicates result exceeded background concentration.
Significant figures were considered when comparing values, but the most precise values are shown in the table.

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Table 3-9. Exceedance Factors for Contaminants of Ecological Concern for which Industrial Land Use Screening Levels Are Available.

Constituent	216-A-29 Ditch	216-B-63 Trench	216-S-10 Ditch	216-S-10 Pond
Metals				
Antimony		19		
Arsenic	1.7			
Cadmium	2.0			
Total chromium			12	
Copper			1.1	
Lead	3.3			
Selenium	8.4	2.5	1.4	1.5
Silver	10		7.2	2.0
Thallium	3.25	3.31	6.19	3.88
Vanadium	1.2	(a)	(a)	
Zinc			1.4	
Organics				
Aroclor-1254	2.9		1.1	
Aroclor-1260		14 (b)		
Dibutyl phthalate	1.3		1.1	
Bis(2-ethylhexyl) phthalate	7.3			
Radionuclides				
Cesium-137	5	5 (b)		
Strontium-90		236 (b)		

(a) Maximum concentration exceeded ecological screening criterion, but was within 95th percentile background.
(b) Sample from E33-333 borehole.

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Table 3-10a. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-A-29 Ditch. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Inorganic Metals (mg/kg)												
Aluminum	10,100	1.8 [6.0] - 2.1 [7.0]	11,800	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Antimony	ND	~	NA	No	Not Evaluated	No	NLA	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Arsenic	12.2	2.6 [8.5] - 2.9 [9.5]	6.47	Yes	3.41E-02	Yes	7.2	4.9 [16.0]	Yes	Yes	Yes	Exceeds cleanup level
Barium	166	79.2 [259.9] - 79.8 [261.9]	132	Yes	1.65E+03	No	166	79.2 [259.9] - 79.8 [261.9]	Yes	No	No	Less than cleanup level
Beryllium	0.68	7.5 [24.5] - 8.2 [27.0]	1.51	No	Not Evaluated	No	0.68	7.5 [24.5] - 8.2 [27.0]	No	No	No	Less than background
Bismuth	0.766	1.2 [4.0] - 2.0 [6.5]	NA	No background	--	No	NLA	~	No	No	Yes	Detected, no background or cleanup level
Boron[e]	3.4	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.28E+01	No	NLA	~	No	No	No	Less than cleanup level
Cadmium	28	1.2 [4.0] - 1.5 [5.0]	1	Yes	6.90E-01	Yes	0.32	4.9 [16.0]	No	No	Yes	Exceeds cleanup level
Calcium	24,300	1.8 [6.0] - 2.1 [7.0]	17,200	Yes	--	No	NLA	~	No	No	No	Essential nutrient
Chromium (total)[h]	36.8	1.2 [4.0] - 1.5 [5.0]	18.5	Yes	2.00E+03	No	36.4	79.2 [259.9] - 79.8 [261.9]	Yes	No	No	Less than cleanup level
Chromium VI	8.8	2.3 [7.5] - 2.6 [8.5]	NA	No background	1.84E+01	No	ND	~	No	No	No	Less than cleanup level
Copper	172	1.2 [4.0] - 1.5 [5.0]	22	Yes	2.63E+02	No	27.3	79.2 [259.9] - 79.8 [261.9]	Yes	No	No	Less than cleanup level
Iron	26,900	1.5 [5.0] - 1.8 [6.0]	32,600	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Lead	390	2.3 [7.5] - 2.6 [8.5]	10.2	Yes	3.00E+03	No	10.5	79.2 [259.9] - 79.8 [261.9]	Yes	No	No	Less than cleanup level
Magnesium	4,310	1.2 [4.0] - 2.0 [6.5]	7,060	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Manganese	454	1.8 [6.0] - 2.1 [7.0]	512	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Mercury	5.2	1.2 [4.0] - 1.5 [5.0]	0.33	Yes	2.09E+00	Yes	0.04	79.2 [259.9] - 79.8 [261.9]	No	No	Yes	Exceeds cleanup level
Molybdenum[e,f]	3.2	1.2 [4.0] - 1.5 [5.0]	NA	No	3.20E-01	Yes	NLA	~	No	No	No	Less than background
Nickel	32.3	79.2 [259.9] - 79.8 [261.9]	19.1	Yes	1.30E+02	No	32.3	79.2 [259.9] - 79.8 [261.9]	Yes	No	No	Less than cleanup level
Potassium	2,260	1.8 [6.0] - 2.1 [7.0]	2,150	Yes	--	No	NLA	~	No	No	No	Essential nutrient
Selenium	2.52	2.7 [9.0] - 3.5 [11.5]	NA	No background	5.20E+00	No	0.68	4.9 [16.0]	No background	No	No	Less than cleanup level
Silver	42	1.2 [4.0] - 1.5 [5.0]	0.73	Yes	1.36E+01	Yes	ND	~	No	No	Yes	Exceeds cleanup level
Sodium	873	1.2 [4.0] - 1.5 [5.0]	690	Yes	--	No	NLA	~	No	No	No	Essential nutrient
Thallium	0.52	1.8 [6.0] - 2.1 [7.0]	NA	No background	1.59E+00	No	NLA	~	No	No	No	Less than cleanup level

Table 3-10a. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-A-29 Ditch. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Tin	ND	~	NA	No	Not Evaluated	No	NLA	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Uranium[h]	5.28	2.3 [7.5] - 2.6 [8.5]	3.21	Yes	6.00E-01	Yes	1.25	4.9 [16.0] - 5.2 [17.0]	No	Yes	Yes	Exceeds cleanup level
Vanadium	104	2.3 [7.5] - 2.6 [8.5]	85.1	Yes	2.24E+03	No	94.2	7.5 [24.5] - 8.2 [27.0]	Yes	No	No	Less than cleanup level
Zinc	224	1.2 [4.0] - 1.5 [5.0]	67.8	Yes	5.97E+03	No	76.9	79.2 [259.9] - 79.8 [261.9]	Yes	No	No	Less than cleanup level
General Inorganic Compounds (mg/kg)												
Ammonia as NH_3	41.7	1.2 [4.0] - 1.5 [5.0]	9.23	Yes	--	No	ND	~	No	No	Yes	Exceeds background, no cleanup level
Bromide	ND	~	NA	No	Not Evaluated	No	NLA	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Chloride[d]	226	1.2 [4.0] - 1.5 [5.0]	100	Yes	1.00E+03	No	4.3	7.5 [24.5] - 8.2 [27.0]	No	No	No	Less than cleanup level
Cyanide	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Fluoride[d]	5.26	2.7 [9.0] - 3.5 [11.5]	2.81	Yes	3.84E+00	Yes	ND	~	No	No	No	Essential nutrient
Hydrazine	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Nitrate as N[d, i]	208.575	1.2 [4.0] - 1.5 [5.0]	12	Yes	1.78E+02	Yes	7.605	4.9 [16.0] - 5.2 [17.0]	No	No	Yes	Exceeds cleanup level
Nitrite as N[d, i]	0.8208	79.2 [259.9] - 79.8 [261.9]	NA	No background	1.32E+01	No	0.8208	79.2 [259.9] - 79.8 [261.9]	No background	No	No	Less than cleanup level
Nitrate/nitrite as N[g]	210	1.2 [4.0] - 1.5 [5.0]	NA	No background	--	No	7.9	4.9 [16.0] - 5.2 [17.0]	No background	No	No	Detected, no background or cleanup level
Phosphate	ND	~	0.785	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Sulfate[d]	2,970	1.2 [4.0] - 1.5 [5.0]	237	Yes	1.00E+03	Yes	46.2	7.5 [24.5] - 8.2 [27.0]	No	No	Yes	Exceeds cleanup level
Sulfide	58.4	79.2 [259.9] - 79.8 [261.9]	NA	No background	--	No	58.4	79.2 [259.9] - 79.8 [261.9]	No background	No	Yes	Detected, no background or cleanup level

Table 3-10a. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-A-29 Ditch. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Organic Compounds (µg/kg)												
1,2-Dichloroethane	13	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.32E+00	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
2-Butanone[d]	2	82.9 [271.9] - 83.5 [273.9]	NA	No background	1.92E+04	No	2	82.9 [271.9] - 83.5 [273.9]	No background	No	No	Less than cleanup level
Acetone	30	2.3 [7.5] - 2.6 [8.5]	NA	No background	3.21E+03	No	14	60.9 [199.9] - 61.5 [201.9]	No background	No	No	Less than cleanup level
Aroclor-1254[h]	9,400	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.31E+03	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Benzo(a)anthracene	180	1.2 [4.0] - 1.5 [5.0]	NA	No background	8.63E+01	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Benzo(a)pyrene	160	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.33E+02	No	ND	~	No background	No	No	Less than cleanup level
Benzo(b)fluoranthene	240	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.88E+02	No	ND	~	No background	No	No	Less than cleanup level
Bis(2-ethylhexyl) phthalate	6,200	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.32E+04	No	52	4.9 [16.0]	No background	No	No	Less than cleanup level
Butyl benzyl phthalate	290	1.2 [4.0] - 1.5 [5.0]	NA	No background	9.09E+05	No	ND	~	No background	No	No	Less than cleanup level
Chrysene	210	1.2 [4.0] - 1.5 [5.0]	NA	No background	9.59E+01	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Dibutyl phthalate	2,741	1.2 [4.0] - 1.5 [5.0]	NA	No background	5.76E+04	No	ND	~	No background	No	No	Less than cleanup level
Diethyl phthalate	330	2.7 [9.0] - 3.5 [11.5]	NA	No background	7.22E+04	No	ND	~	No background	No	No	Less than cleanup level
Fluoranthene	370	1.2 [4.0] - 1.5 [5.0]	NA	No background	6.30E+05	No	ND	~	No background	No	No	Less than cleanup level
Kerosene range TPH	440,000	1.2 [4.0] - 2.0 [6.5]	NA	No background	2.00E+06	No	ND	~	No background	No	No	Less than cleanup level
Mesityl oxide	390	2.7 [9.0] - 3.5 [11.5]	NA	No background	--	No	NLA	~	No background	No	Yes	Detected, no background or cleanup level
Methylene chloride	78	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.18E+01	Yes	36	79.2 [259.9] - 79.8 [261.9]	No background	Yes	Yes	Exceeds cleanup level
Motor oil TPH	760,000	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.00E+06	No	NLA	~	No background	No	No	Less than cleanup level
N-Butylbenzenesulfonamide	4,400	2.7 [9.0] - 3.5 [11.5]	NA	No background	--	No	NLA	~	No background	No	Yes	Detected, no background or cleanup level
Phenanthrene[h,j]	370	1.2 [4.0] - 1.5 [5.0]	NA	No background	2.23E+06	No	ND	~	No background	No	No	Less than cleanup level
Pyrene	350	1.2 [4.0] - 1.5 [5.0]	NA	No background	6.55E+05	No	ND	~	No background	No	No	Less than cleanup level

Table 3-10a. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-A-29 Ditch. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Tetrachloroethylene	6	1.2 [4.0] - 1.5 [5.0]	NA	No background	8.67E-01	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Toluene	1	79.2 [259.9] - 79.8 [261.9]	NA	No background	4.65E+03	No	1	79.2 [259.9] - 79.8 [261.9]	No background	No	No	Less than cleanup level
Tributyl phosphate[h]	543	1.2 [4.0] - 2.0 [6.5]	NA	No background	3.24E+01	Yes	ND	~	No background	No	Yes	Exceeds cleanup level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Unless otherwise noted in Table F-4, the protection of groundwater soil cleanup levels reported in this table were calculated using Equation 747-1 of the MTCA Cleanup Regulation (WAC 173-340-747) and values reported in the CLARC online database as of 2/6/07. Where Henry's Law Constant (Hcc) and distribution coefficient (Kd) values were unavailable, conservative estimates of zero were assumed for screening purposes.

[c]Deep-zone maximum concentration determination included all samples deeper than the 4.6 m [15 ft] depth. A sample was included only if the highest point of the sample depth range was greater than 4.6 m [15 ft] (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample, while a sample collected from 4.9 to 5.2 m [16 to 17 ft] would be considered a deep-zone sample.

[d]In order to calculate the protection of groundwater soil cleanup level, conservative estimates of zero were assumed for both the Hcc and the Kd of this constituent.

[e]In order to calculate the protection of groundwater soil cleanup level, a conservative estimate of zero was assumed for the Kd of this constituent.

[f]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[g] Nitrate/Nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.

[h] Alternative Hcc and Kd values were used to calculate the cleanup level for this constituent. These alternative values are listed in Table F-4.

[i]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[j]A cleanup level for this constituent was unavailable, so the cleaup level for anthracene was used.

WAC = Washington State Administrative Code.
bgs = below ground surface.
GW = groundwater.
COC = Contaminant of Concern.
ND = included in analysis but not detected.
NLA = no laboratory analysis conducted.
TPH = total petroleum hydrocarbons.
-- = no cleanup level is available.
Shading indicates that the chemical was retained as a contaminant of concern.
Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-10b. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-B-63 Trench. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Inorganic Metals (mg/kg)												
Aluminum	7,090	3.2 [10.5] - 4.0 [13.0]	11,800	No	Not Evaluated	No	6,980	30.5 [100.0] - 31.2 [102.5]	No	No	No	Less than background
Antimony	5	1.2 [4.0] - 2.0 [6.5]	NA	No background	5.42E+00	No	ND	~	No	No	No	Less than cleanup level
Arsenic	5.1	4.6 [15.0] - 5.2 [17.0]	6.47	No	Not Evaluated	No	4.5	7.3 [24.0] - 7.6 [25.0]	No	No	No	Less than background
Barium	96.9	2.3 [7.5] - 2.6 [8.5]	132	No	Not Evaluated	No	80.7	5.2 [17.0] - 5.5 [18.0]	No	No	No	Less than background
Beryllium	0.913	5.3 [17.5] - 5.8 [19.0]	1.51	No	Not Evaluated	No	0.913	5.3 [17.5] - 5.8 [19.0]	No	No	No	Less than background
Bismuth	37.1	2.4 [8.0] - 3.2 [10.5]	NA	No background	--	No	26.2	30.5 [100.0] - 31.2 [102.5]	No background	No	Yes	Detected, no background or cleanup level
Boron[e]	6.3	2.4 [8.0] - 3.2 [10.5]	NA	No background	1.28E+01	No	5	22.9 [75.0] - 23.6 [77.5]	No background	No	No	Less than cleanup level
Cadmium	2.42	5.3 [17.5] - 5.8 [19.0]	1	Yes	6.90E-01	Yes	2.42	5.3 [17.5] - 5.8 [19.0]	Yes	Yes	Yes	Exceeds cleanup level
Calcium	16,100	12.2 [40.0] - 12.8 [42.0]	17,200	No	Not Evaluated	No	16,100	12.2 [40.0] - 12.8 [42.0]	No	No	No	Less than background
Chromium (total)	21.9	3.8 [12.5] - 4.4 [14.5]	18.5	Yes	2.00E+03	No	16.5	5.3 [17.5] - 5.8 [19.0]	No	No	No	Less than background
Chromium VI	0.483	5.3 [17.5] - 5.8 [19.0]	NA	No background	1.84E+01	No	0.483	5.3 [17.5] - 5.8 [19.0]	No background	No	No	Less than cleanup level
Cobalt	11.4	2.4 [8.0] - 3.2 [10.5]	15.7	No	Not Evaluated	No	7.2	53.0 [174.0] - 54.6 [179.0]	No	No	No	Less than background
Copper	30.6	3.7 [12.0] - 4.0 [13.0]	22	Yes	2.63E+02	No	14.8	53.0 [174.0] - 54.6 [179.0]	No	No	No	Less than cleanup level
Iron	28,400	1.8 [6.0] - 2.1 [7.0]	32,600	No	Not Evaluated	No	16,700	53.0 [174.0] - 54.6 [179.0]	No	No	No	Less than background
Lead	7.5	2.4 [8.0] - 3.2 [10.5]	10.2	No	Not Evaluated	No	4.8	9.1 [30.0] - 9.9 [32.5]	No	No	No	Less than background
Magnesium	5,600	30.5 [100.0] - 31.2 [102.5]	7,060	No	Not Evaluated	No	5,600	30.5 [100.0] - 31.2 [102.5]	No	No	No	Less than background
Manganese	410	1.8 [6.0] - 2.1 [7.0]	512	No	Not Evaluated	No	330	9.1 [30.0] - 9.9 [32.5]	No	No	No	Less than background
Mercury	0.15	4.0 [13.0] - 4.7 [15.5]	0.33	No	Not Evaluated	No	ND	~	No	No	No	Less than background

Table 3-10b. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-B-63 Trench. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Molybdenum[e,f]	0.55	1.5 [5.0] - 1.8 [6.0]	NA	No	3.20E-01	Yes	ND	~	No	No	No	Less than background
Nickel	21	5.9 [19.5] - 6.6 [21.5]	19.1	Yes	1.30E+02	No	21	5.9 [19.5] - 6.6 [21.5]	Yes	No	No	Less than cleanup level
Potassium	1,740	1.5 [5.0] - 1.8 [6.0]	2,150	No	Not Evaluated	No	1,490	53.0 [174.0] - 54.6 [179.0]	No	No	No	Less than background
Selenium	0.75	2.3 [7.5] - 2.6 [8.5]	NA	No background	5.20E+00	No	0.5	22.9 [75.0] - 23.6 [77.5]	No background	No	No	Less than cleanup level
Silver	0.86	2.4 [8.0] - 3.2 [10.5]	0.73	Yes	1.36E+01	No	0.79	22.9 [75.0] - 23.6 [77.5]	Yes	No	No	Less than cleanup level
Sodium	671	3.2 [10.5] - 4.0 [13.0]	690	No	Not Evaluated	No	281	6.1 [20.0] - 6.9 [22.5]	No	No	No	Less than background
Thallium	0.53	1.8 [6.0] - 2.1 [7.0]	NA	No background	1.59E+00	No	NLA	~	No	No	No	Less than cleanup level
Tin	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Uranium	2.38	4.0 [13.0] - 4.7 [15.5]	3.21	No	Not Evaluated	No	2.2	9.1 [30.0] - 9.9 [32.5]	No	No	No	Less than background
Vanadium	86.9	2.3 [7.5] - 2.6 [8.5]	85.1	Yes	2.24E+03	No	64.2	5.2 [17.0] - 5.5 [18.0]	No	No	No	Less than cleanup level
Zinc	80.8	3.7 [12.0] - 4.0 [13.0]	67.8	Yes	5.97E+03	No	45.2	5.2 [17.0] - 5.5 [18.0]	No	No	No	Less than cleanup level
General Inorganic Compounds (mg/kg)												
Ammonia as NH_3[f]	9.99	4.6 [15.0] - 5.2 [17.0]	9.23	No	Not Evaluated	No	ND	~	No	No	No	Less than background
Bromide	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Chloride	17.9	1.5 [5.0] - 1.8 [6.0]	100	No	Not Evaluated	No	3.75	5.9 [19.5] - 6.6 [21.5]; 16.2 [53.0] - 16.8 [55.0]	No	No	No	Less than background
Cyanide	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Fluoride	0.76	2.3 [7.5] - 2.6 [8.5]	2.81	No	Not Evaluated	No	0.263	5.3 [17.5] - 5.8 [19.0]	No	No	No	Less than background
Hydrazine	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted

Table 3-10b. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-B-63 Trench. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Nitrate as N[d, h]	187.425	1.5 [5.0] - 1.8 [6.0]	12	Yes	1.78E+02	Yes	8.0325	5.2 [17.0] - 5.5 [18.0]	No	No	Yes	Exceeds cleanup level
Nitrite as N[d, h]	0.380	1.2 [4.0] - 2.0 [6.5]	NA	No background	1.32E+01	No	ND	~	No	No	No	Less than cleanup level
Nitrate/nitrite as N[g]	230	1.5 [5.0] - 1.8 [6.0]	NA	No background	--	No	8.5	5.2 [17.0] - 5.5 [18.0]	No background	No	No	Detected, no background or cleanup level
Phosphate	6.4	2.1 [7.0] - 2.4 [8.0]	0.785	Yes	--	No	ND	~	No	No	Yes	Exceeds background, no cleanup level
Sulfate	76.2	1.5 [5.0] - 1.8 [6.0]	237	No	Not Evaluated	No	18.4	76.6 [251.4] - 77.4 [253.9]	No	No	No	Less than background
Sulfide	43.8	3.4 [11.0] - 3.7 [12.0]	NA	No background	--	No	38.8	5.9 [19.5] - 6.6 [21.5]	No background	No	Yes	Detected, no background or cleanup level
Organic Compounds (μg/kg)												
1,2,4-Trimethylbenzene[d]	10	45.7 [150.0] - 46.3 [152.0]	NA	No background	1.60E+03	No	10	45.7 [150.0] - 46.3 [152.0]	No background	No	No	Less than cleanup level
2-Ethylhexanol	240	76.6 [251.4] - 77.4 [253.9]	NA	No background	--	No	240	76.6 [251.4] - 77.4 [253.9]	No background	No	Yes	Detected, no background or cleanup level
Acetone	66	1.5 [5.0] - 1.8 [6.0]	NA	No background	3.21E+03	No	22	76.6 [251.4] - 77.4 [253.9]	No background	No	No	Less than cleanup level
Aroclor-1254[d, i]	77	3.0 [10.0] - 4.0 [13.0]	NA	No background	1.31E+03	No	ND	~	No background	No	No	Less than cleanup level
Aroclor-1260[i]	9,200	2.4 [8.0] - 3.2 [10.5]	NA	No background	7.18E+02	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Benzene	8	1.5 [5.0] - 1.8 [6.0]	NA	No background	4.49E+00	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Bis(2-ethylhexyl) phthalate	54	7.3 [24.0] - 7.6 [25.0]	NA	No background	1.32E+04	No	54	7.3 [24.0] - 7.6 [25.0]	No background	No	No	Less than cleanup level
Butyl benzyl phthalate	240	76.6 [251.4] - 77.4 [253.9]	NA	No background	9.09E+05	No	240	76.6 [251.4] - 77.4 [253.9]	No background	No	No	Less than cleanup level
Dibutyl phthalate	21	30.8 [101.0] - 31.4 [103.0]	NA	No background	5.76E+04	No	21	30.8 [101.0] - 31.4 [103.0]	No background	No	No	Less than cleanup level
Diethyl phthalate	210	5.3 [17.5] - 5.8 [19.0]	NA	No background	7.22E+04	No	210	5.3 [17.5] - 5.8 [19.0]	No background	No	No	Less than cleanup level
Di-n-octyl phthalate	52	4.0 [13.0] - 4.7 [15.5]	NA	No background	5.31E+08	No	ND	~	No background	No	No	Less than cleanup level
Hexadecanoic acid (9CI)	740	76.6 [251.4] - 77.4 [253.9]	NA	No background	--	No	740	76.6 [251.4] - 77.4 [253.9]	No background	No	Yes	Detected, no background or cleanup level
Methylene chloride	27	2.9 [9.5] - 3.2 [10.5]	NA	No background	2.18E+01	Yes	16	5.2 [17.0] - 5.5 [18.0]	No background	No	Yes	Exceeds cleanup level

Table 3-10b. Groundwater Pathway Soil Cleanup Levels & Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-B-63 Trench. (4 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6 m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Octadecanoic acid	140	76.6 [251.4] - 77.4 [253.9]	NA	No background	--	No	140	76.6 [251.4] - 77.4 [253.9]	No background	No	Yes	Detected, no background or cleanup level
Toluene	3	2.1 [7.0] - 2.4 [8.0]	NA	No background	4.65E+03	No	2	45.7 [150.0] - 46.3 [152.0]	No background	No	No	Less than cleanup level
Xylenes (total)	8	45.7 [150.0] - 46.3 [152.0]	NA	No background	1.45E+04	No	8	45.7 [150.0] - 46.3 [152.0]	No background	No	No	Less than cleanup level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Unless otherwise noted in Table F-4, the protection of groundwater soil cleanup levels reported in this table were calculated using Equation 747-1 of the MTCA Cleanup Regulation (WAC 173-340-747) and values reported in the CLARC online database as of 2/6/07. Where Henry's Law Constant (Hcc) and distribution coefficient (Kd) values were unavailable, conservative estimates of zero were assumed for screening purposes.

[c]Deep-zone maximum concentration determination included all samples deeper than the 4.6 m [15 ft] depth. A sample was included only if the highest point of the sample depth range was greater than 4.6 m [15 ft] (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample, while a sample collected from 4.9 to 5.2 m [16 to 17 ft] would be considered a deep-zone sample.

[d]In order to calculate the protection of groundwater soil cleanup level, conservative estimates of zero were assumed for both the Hcc and the Kd of this constituent.

[e]In order to calculate the protection of groundwater soil cleanup level, a conservative estimate of zero was assumed for the Kd of this constituent.

[f]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[g] Nitrate/Nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.

[h]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[i] Alternative Hcc and Kd values were used to calculate the cleanup level for this constituent. These alternative values are listed in Table F-4.

WAC = Washington State Administrative Code.

bgs = below ground surface.

GW = groundwater.

COC = Contaminant of Concern.

ND = included in analysis but not detected.

NLA = no laboratory analysis conducted.

TPH = total petroleum hydrocarbons.

-- = no cleanup level is available.

Shading indicates that the chemical was retained as a contaminant of concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-10c. Protection of Groundwater Soil Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Ditch. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Levels for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Inorganic Metals (mg/kg)												
Aluminum	10,800	0.0 [0.0] - 0.5 [1.5]	11,800	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Antimony	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Arsenic[f]	6.7	41.1 [135.0] - 41.8 [137.0]	6.47	No	Not Evaluated	No	6.7	41.1 [135.0] - 41.8 [137.0]	Yes	No	No	Less than background
Barium	120	0.9 [3.0] - 1.2 [4.0]	132	No	Not Evaluated	No	114	15.2 [50.0] - 15.8 [52.0]	No	No	No	Less than background
Beryllium	0.653	7.6 [25.0] - 8.2 [27.0]	1.51	No	Not Evaluated	No	0.653	7.6 [25.0] - 8.2 [27.0]	No	No	No	Less than background
Bismuth	2	0.0 [0.0] - 0.5 [1.5]	NA	No background	--	No	0.000594	7.6 [25.0] - 8.2 [27.0]	No background	No	Yes	Detected, no background or cleanup level
Boron[e]	1.5	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.28E+01	No	NLA	~	No	No	No	Less than cleanup level
Cadmium	2.26	~	1	Yes	6.90E-01	Yes	2.26	7.6 [25.0] - 8.2 [27.0]	Yes	Yes	Yes	Exceeds cleanup level
Calcium	3,880	0.9 [3.0] - 1.2 [4.0]	17,200	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Chromium (total)[i]	815	0.0 [0.0] - 0.5 [1.5]	18.5	Yes	2.00E+03	No	29.8	67.1 [220.0] - 67.7 [222.0]	Yes	No	No	Less than cleanup level
Chromium VI	14.1	0.5 [1.5] - 0.9 [3.0]	NA	No background	1.84E+01	No	1.8	60.9 [199.9] - 61.5 [201.9]	No background	No	No	Less than cleanup level
Copper	244	0.0 [0.0] - 0.5 [1.5]	22	Yes	2.63E+02	No	20	56.4 [185.0] - 57.0 [187.0]	No	No	No	Less than cleanup level
Iron	28,800	0.0 [0.0] - 0.5 [1.5]	32,600	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Lead	30	0.0 [0.0] - 0.5 [1.5]	10.2	Yes	3.00E+03	No	8.9	41.1 [135.0] - 41.8 [137.0]	No	No	No	Less than cleanup level
Magnesium	4,370	0.9 [3.0] - 1.2 [4.0]	7,060	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Manganese	451	0.9 [3.0] - 1.2 [4.0]	512	No	Not Evaluated	No	257	7.6 [25.0] - 8.2 [27.0]	No	No	No	Less than background

Table 3-10c. Protection of Groundwater Soil Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Ditch. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Levels for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Mercury	4.3	0.0 [0.0] - 0.5 [1.5]	0.33	Yes	2.09E+00	Yes	0.016	~	No	No	Yes	Exceeds cleanup level
Molybdenum[e,f]	0.88	0.0 [0.0] - 0.5 [1.5]	NA	No	3.20E-01	Yes	0.342	7.6 [25.0] - 8.2 [27.0]	No background	Yes	No	Less than background
Nickel	20.8	45.7 [150.0] - 46.3 [152.0]	19.1	Yes	1.30E+02	No	20.8	45.7 [150.0] - 46.3 [152.0]	Yes	No	No	Less than cleanup level
Potassium	856	0.9 [3.0] - 1.2 [4.0]	2,150	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Selenium	1.9	7.6 [25.0] - 8.2 [27.0]	NA	No background	5.20E+00	No	1.9	7.6 [25.0] - 8.2 [27.0]	No background	No	No	Less than cleanup level
Silver	30.4	0.0 [0.0] - 0.5 [1.5]	0.73	Yes	1.36E+01	Yes	0.082	7.6 [25.0] - 8.2 [27.0]	No	No	Yes	Exceeds cleanup level
Sodium	176	0.0 [0.0] - 0.5 [1.5]	690	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Thallium	0.99	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.59E+00	No	NLA	~	No	No	No	Less than cleanup level
Tin	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Uranium	1.49	2.6 [8.5] - 2.9 [9.5]	3.21	No	Not Evaluated	No	0.833	41.1 [135.0] - 41.8 [137.0]	No	No	No	Less than background
Vanadium	131	60.9 [199.9] - 61.5 [201.9]	85.1	Yes	2.24E+03	No	131	60.9 [199.9] - 61.5 [201.9]	Yes	No	No	Less than cleanup level
Zinc	506	0.0 [0.0] - 0.5 [1.5]	67.8	Yes	5.97E+03	No	76	56.4 [185.0] - 57.0 [187.0]	Yes	No	No	Less than cleanup level
General Inorganic Compounds (mg/kg)												
Ammonia as NH_3	3.45	6.1 [20.0] - 6.7 [22.0]	9.23	No	Not Evaluated	No	3.45	6.1 [20.0] - 6.7 [22.0]	No	No	No	Less than background
Bromide	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Chloride	31.9	6.1 [20.0] - 6.7 [22.0]	100	No	Not Evaluated	No	31.9	6.1 [20.0] - 6.7 [22.0]	No	No	No	Less than background

Table 3-10c. Protection of Groundwater Soil Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Ditch. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Levels for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Cyanide	ND	~	NA	No	Not Evaluated	No	ND	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Fluoride	0.718	7.6 [25.0] - 8.2 [27.0]	2.81	No	Not Evaluated	No	0.718	7.6 [25.0] - 8.2 [27.0]	No	No	No	Less than background
Nitrate as N[d, h]	18.135	4.9 [16.0] - 5.2 [17.0]	12	Yes	1.78E+02	No	18.135	4.9 [16.0] - 5.2 [17.0]	Yes	No	No	Less than cleanup level
Nitrite as N[d, h]	0.3496	2.9 [9.5] - 3.2 [10.5]	NA	No background	1.32E+01	No	ND	~	No background	No	No	Less than cleanup level
Nitrate/nitrite as N[g]	10.6	0.0 [0.0] - 0.5 [1.5]	NA	No background	--	No	1.4	7.6 [25.0] - 8.2 [27.0]	No background	No	No	Detected, no background or cleanup level
Phosphate	2.4	60.9 [199.9] - 61.5 [201.9]	0.785	Yes	--	No	2.4	60.9 [199.9] - 61.5 [201.9]	Yes	No	Yes	Exceeds background, no cleanup level
Sulfate	199	0.0 [0.0] - 0.5 [1.5]	237	No	Not Evaluated	No	36.2	6.1 [20.0] - 6.7 [22.0]	No	No	No	Less than background
Sulfide	97.4	7.6 [25.0] - 8.2 [27.0]	NA	No background	--	No	97.4	7.6 [25.0] - 8.2 [27.0]	No background	No	Yes	Detected, no background or cleanup level
Organic Compounds (µg/kg)												
Acenaphthene	61	0.0 [0.0] - 0.5 [1.5]	NA	No background	9.79E+04	No	ND	~	No background	No	No	Less than cleanup level
Acetone	10	4.9 [16.0] - 5.2 [17.0]	NA	No background	3.21E+03	No	10	4.9 [16.0] - 5.2 [17.0]	No background	No	No	Less than cleanup level
Anthracene	150	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.23E+06	No	ND	~	No background	No	No	Less than cleanup level
Aroclor-1254[d, i]	3,700	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.31E+03	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Benzo(a)anthracene	550	0.0 [0.0] - 0.5 [1.5]	NA	No background	8.63E+01	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Benzo(a)pyrene	600	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.33E+02	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Benzo(b)fluoranthene	530	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.88E+02	Yes	ND	~	No background	No	Yes	Exceeds cleanup level

Table 3-10c. Protection of Groundwater Soil Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Ditch. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Levels for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Benzo(g,h,i)perylene[j]	660	0.0 [0.0] - 0.5 [1.5]	NA	No background	6.55E-01	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Benzo(k)fluoranthene	450	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.88E+02	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Bis(2-ethylhexyl) phthalate	580	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.38E+04	No	68.974	6.1 [20.0] - 6.7 [22.0]	No background	No	No	Less than cleanup level
Butyl benzyl phthalate	580	0.0 [0.0] - 0.5 [1.5]	NA	No background	9.09E+05	No	ND	~	No background	No	No	Less than cleanup level
Butyl stearate	230	7.6 [25.0] - 8.2 [27.0]	NA	No background	--	No	230	7.6 [25.0] - 8.2 [27.0]	No background	No	Yes	Detected, no background or cleanup level
Carbazole	97	0.0 [0.0] - 0.5 [1.5]	NA	No background	3.15E+02	No	ND	~	No background	No	No	Less than cleanup level
Chrysene	680	0.0 [0.0] - 0.5 [1.5]	NA	No background	9.59E+01	Yes	ND	~	No background	No	Yes	Exceeds cleanup level
Dibenzo[a,h]anthracene	110	0.0 [0.0] - 0.5 [1.5]	NA	No background	4.32E+02	No	ND	~	No background	No	No	Less than cleanup level
Dibutyl phthalate	2,300	0.0 [0.0] - 0.5 [1.5]	NA	No background	5.76E+04	No	170	4.9 [16.0] - 5.2 [17.0]	No background	No	No	Less than cleanup level
Diesel Range TPH	31,000	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.00E+06	No	ND	~	No background	No	No	Less than cleanup level
Diethyl phthalate	360	7.6 [25.0] - 8.2 [27.0]	NA	No background	7.22E+04	No	360	7.6 [25.0] - 8.2 [27.0]	No background	No	No	Less than cleanup level
Eicosane	170	7.6 [25.0] - 8.2 [27.0]	NA	No background	--	No	170	7.6 [25.0] - 8.2 [27.0]	No background	No	Yes	Detected, no background or cleanup level
Fluoranthene	1,500	0.0 [0.0] - 0.5 [1.5]	NA	No background	6.30E+05	No	ND	~	No background	No	No	Less than cleanup level
Fluorene	59	0.0 [0.0] - 0.5 [1.5]	NA	No background	1.01E+05	No	ND	~	No background	No	No	Less than cleanup level
Hexadecanoic acid, butyl ester	300	7.6 [25.0] - 8.2 [27.0]	NA	No background	--	No	300	7.6 [25.0] - 8.2 [27.0]	No background	No	Yes	Detected, no background or cleanup level
Indeno(1,2,3-cd)pyrene	400	0.0 [0.0] - 0.5 [1.5]	NA	No background	8.39E+02	No	ND	~	No background	No	No	Less than cleanup level

Table 3-10c. Protection of Groundwater Soil Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Ditch. (5 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Levels for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	COC?	JUSTIFICATION
Methylene chloride	18	45.7 [150.0] - 46.3 [152.0]; 56.4 [185.0] - 57.0 [187.0]	NA	No background	2.18E+01	No	18	~	No background	No	No	Less than cleanup level
Phenanthrene[i, k]	930	0.0 [0.0] - 0.5 [1.5]	NA	No background	2.23E+06	No	ND	~	No background	No	No	Less than cleanup level
Pyrene	1,600	0.0 [0.0] - 0.5 [1.5]	NA	No background	6.55E+05	No	ND	~	No background	No	No	Less than cleanup level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Unless otherwise noted in Table F-4, the protection of groundwater soil cleanup levels reported in this table were calculated using Equation 747-1 of the MTCA Cleanup Regulation (WAC 173-340-747) and values reported in the CLARC online database as of 2/6/07. Where Henry's Law Constant (Hcc) and distribution coefficient (Kd) values were unavailable, conservative estimates of zero were assumed for screening purposes.

[c]Deep-zone maximum concentration determination included all samples deeper than the 4.6 m [15 ft] depth. A sample was included only if the highest point of the sample depth range was greater than 4.6 m [15 ft] (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample, while a sample collected from 4.9 to 5.2 m [16 to 17 ft] would be considered a deep-zone sample.

[d]In order to calculate the protection of groundwater soil cleanup level, conservative estimates of zero were assumed for both the Hcc and the Kd of this constituent.

[e]In order to calculate the protection of groundwater soil cleanup level, a conservative estimate of zero was assumed for the Kd of this constituent.

[f]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[g] Nitrate/Nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.

[h]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[i] Alternative Hcc and Kd values were used to calculate the cleanup level for this constituent. These alternative values are listed in Table F-4.

[j]A cleanup level for this constituent was unavailable, so the cleanup level for pyrene was used.

[k]A cleanup level for this constituent was unavailable, so the cleanup level for anthracene was used.

WAC = Washington State Administrative Code.

bgs = below ground surface.

GW = groundwater.

COC = Contaminant of Concern.

ND = included in analysis but not detected.

NLA = no laboratory analysis conducted.

TPH = total petroleum hydrocarbons.

-- = no cleanup level is available.

Shading indicates that the chemical was retained as a contaminant of concern.

Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-10d. Groundwater Pathway Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Pond. (3 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	Screen COC?	JUSTIFICATION
Inorganic Metals (mg/kg)												
Aluminum	5870	1.8 [6.0] - 2.1 [7.0]	11800	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Arsenic	5.6	2.0 [6.5] - 2.3 [7.5]	6.47	No	Not Evaluated	No	5.3	30.3 [99.5] - 30.9 [101.5]	No	No	No	Less than background
Barium	180	6.1 [20.0] - 6.4 [21.0]	132	Yes	1.65E+03	No	180	6.1 [20.0] - 6.4 [21.0]	Yes	No	No	Less than cleanup level
Beryllium	0.45	45.8 [150.1] - 46.4 [152.1]	1.51	No	Not Evaluated	No	0.45	45.8 [150.1] - 46.4 [152.1]	No	No	No	Less than background
Bismuth	ND	~	NA	No	Not Evaluated	No	NLA	~	No	No	No	Not detected at waste site or no laboratory analysis conducted
Boron[e]	1	1.8 [6.0] - 2.1 [7.0]	NA	No background	1.28E+01	No	NLA	~	No	No	No	Less than cleanup level
Cadmium	0.5	54.8 [179.9] - 55.4 [181.9]	1	No	6.90E-01	No	0.5	54.8 [179.9] - 55.4 [181.9]	No	No	No	Less than cleanup level
Calcium	11100	1.2 [4.0] - 1.5 [5.0]	17200	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Chromium (total)[i]	39	60.2 [197.4] - 60.7 [199.3]	18.5	Yes	2.00E+03	No	39	60.2 [197.4] - 60.7 [199.3]	Yes	No	No	Less than cleanup level
Chromium VI	2.7	2.1 [7.0] - 2.4 [8.0]	NA	No background	1.84E+01	No	1.57	6.1 [20.0] - 6.4 [21.0]	No background	No	No	Less than cleanup level
Copper	21.3	4.9 [16.0] - 5.2 [17.0]	22	No	Not Evaluated	No	21.3	4.9 [16.0] - 5.2 [17.0]	No	No	No	Less than background
Iron	25100	~	32600	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Lead	10.3	15.2 [50.0] - 15.8 [52.0]	10.2	Yes	3.00E+03	No	10.3	15.2 [50.0] - 15.8 [52.0]	Yes	No	No	Less than cleanup level
Magnesium	4780	1.2 [4.0] - 1.5 [5.0]	7060	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Manganese	392	1.8 [6.0] - 2.1 [7.0]	512	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Mercury	0.43	3.5 [11.5] - 3.8 [12.5]	0.33	Yes	2.09E+00	No	0.26	5.2 [17.0] - 5.5 [18.0]	No	No	No	Less than cleanup level
Molybdenum[e,f]	0.29	2.0 [6.5] - 2.3 [7.5]	NA	No	3.20E-01	No	NLA	~	No	No	No	Less than background
Nickel	25.2	60.2 [197.4] - 60.7 [199.3]	19.1	Yes	1.30E+02	No	25.2	60.2 [197.4] - 60.7 [199.3]	Yes	No	No	Less than cleanup level
Potassium	1230	1.8 [6.0] - 2.1 [7.0]	2150	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Selenium	2	54.8 [179.9] - 55.4 [181.9]	NA	No background	5.20E+00	No	2	54.8 [179.9] - 55.4 [181.9]	No background	No	No	Less than cleanup level
Silver	8.3	2.7 [9.0] - 3.0 [10.0]	0.73	Yes	1.36E+01	No	0.47	5.2 [17.0] - 5.5 [18.0]	No	No	No	Less than cleanup level

Table 3-10d. Groundwater Pathway Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Pond. (3 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	Screen COC?	JUSTIFICATION
Sodium	193	2.0 [6.5] - 2.3 [7.5]	690	No	Not Evaluated	No	NLA	~	No	No	No	Less than background
Thallium	0.62	1.2 [4.0] - 1.5 [5.0]	NA	No background	1.59E+00	No	NLA	~	No	No	No	Less than cleanup level
Uranium	2.14	10.7 [35.0] - 11.3 [37.0]	3.21	No	Not Evaluated	No	2.14	10.7 [35.0] - 11.3 [37.0]	No	No	No	Less than background
Vanadium	87.5	45.8 [150.1] - 46.4 [152.1]	85.1	Yes	2.24E+03	No	87.5	45.8 [150.1] - 46.4 [152.1]	Yes	No	No	Less than cleanup level
Zinc	201	60.2 [197.4] - 60.7 [199.3]	67.8	Yes	5.97E+03	No	201	60.2 [197.4] - 60.7 [199.3]	Yes	No	No	Less than cleanup level
General Inorganic Compounds (mg/kg)												
Ammonia as NH_3	2.07	15.2 [50.0] - 15.8 [52.0]	9.23	No	Not Evaluated	No	2.07	15.2 [50.0] - 15.8 [52.0]	No	No	No	Less than background
Chloride	3.96	4.9 [16.0] - 5.2 [17.0]	100	No	Not Evaluated	No	3.96	4.9 [16.0] - 5.2 [17.0]	No	No	No	Less than background
Cyanide[d]	0.2	2.9 [9.5] - 3.2 [10.5]	NA	No background	8.00E-01	No	ND	~	No	No	No	Less than cleanup level
Fluoride	1.1	2.9 [9.5] - 3.2 [10.5]	2.81	No	Not Evaluated	No	ND	~	No	No	No	Less than background
Nitrate as N[d, h]	30.15	4.9 [16.0] - 5.2 [17.0]	12	Yes	1.78E+02	No	30.15	4.9 [16.0] - 5.2 [17.0]	Yes	No	No	Less than cleanup level
Nitrite as N[d, h]	0.48032	2.9 [9.5] - 3.2 [10.5]	NA	No background	1.32E+01	No	ND	~	No	No	No	Less than cleanup level
Nitrate/nitrite as N[g]	22.7	4.9 [16.0] - 5.2 [17.0]	NA	No background	--	No	22.7	4.9 [16.0] - 5.2 [17.0]	No background	No	No	Detected, no background or cleanup level
Phosphate	3.8	3.5 [11.5] - 3.8 [12.5]	0.785	Yes	--	No	2.6	54.8 [179.9] - 55.4 [181.9]	Yes	No	Yes	Exceeds background, no cleanup level
Sulfate	12.4	54.8 [179.9] - 55.4 [181.9]	237	No	Not Evaluated	No	12.4	54.8 [179.9] - 55.4 [181.9]	No	No	No	Less than background
Sulfide	59	3.4 [11.0] - 3.7 [12.0]	NA	No background	--	No	43.8	7.3 [24.0] - 7.6 [25.0]	No background	No	Yes	Detected, no background or cleanup level
Organic Compounds (µg/kg)												
2-Butanone[e]	12	30.3 [99.5] - 30.9 [101.5]	NA	No background	1.92E+04	No	12	30.3 [99.5] - 30.9 [101.5]	No background	No	No	Less than cleanup level
Acetone	33	30.3 [99.5] - 30.9 [101.5]	NA	No background	3.21E+03	No	33	30.3 [99.5] - 30.9 [101.5]	No background	No	No	Less than cleanup level
Bis(2-ethylhexyl)phthalate	260	54.8 [179.9] - 55.4 [181.9]	NA	No background	1.38E+04	No	260	54.8 [179.9] - 55.4 [181.9]	No background	No	No	Less than cleanup level
Dibutyl phthalate	100	7.3 [24.0] - 7.6 [25.0]	NA	No background	5.76E+04	No	100	7.3 [24.0] - 7.6 [25.0]	No background	No	No	Less than cleanup level

Table 3-10d. Groundwater Pathway Cleanup Levels and Contaminants of Concern for Chemicals in Deep-Zone Soils (0 m to Groundwater [0 ft to Groundwater] and 4.6 m to Groundwater [15 ft to Groundwater]) at the 216-S-10 Pond. (3 sheets)

Constituent Name[a]	Maximum Detected Concentration from 0 m to GW	Depth of Maximum Detected from 0 m to GW (m [ft] bgs)	90th Percentile Background Concentration	Does Maximum Detected from 0 m to GW Exceed Background?	Soil Cleanup Level for the Protection of Groundwater[b]	Does Maximum Detected from 0 m to GW Exceed Cleanup Level?	Maximum Detected Result from 4.6m to GW[c]	Depth of Maximum Detected from 4.6 m to GW (m [ft] bgs)	Does Maximum Detected from 4.6 m to GW Exceed Background?	Does Maximum Detected from 4.6 m to GW Exceed Cleanup Level?	Screen COC?	JUSTIFICATION
Methylene chloride	23	4.9 [16.0] - 5.2 [17.0]	NA	No background	2.18E+01	Yes	23	4.9 [16.0] - 5.2 [17.0]	No background	Yes	Yes	Exceeds cleanup level
Toluene	4.2	2.9 [9.5] - 3.2 [10.5]	NA	No background	4.65E+03	No	ND	~	No background	No	No	Less than cleanup level
Xylenes (total)	1.388	1.8 [6.0] - 2.1 [7.0]	NA	No background	1.45E+04	No	ND	~	No background	No	No	Less than cleanup level

[a]Organic constituents that only have non-detect results for all analyzed samples are not included in this table; these constituents are instead summarized in Appendix A.

[b]Unless otherwise noted in Table F-4, the protection of groundwater soil cleanup levels reported in this table were calculated using Equation 747-1 of the MTCA Cleanup Regulation (WAC 173-340-747) and values reported in the CLARC online database as of 2/6/07. Where Henry's Law Constant (Hcc) and distribution coefficient (Kd) values were unavailable, conservative estimates of zero were assumed for screening purposes.

[c]Deep-zone maximum concentration determination included all samples deeper than the 4.6 m [15 ft] depth. A sample was included only if the highest point of the sample depth range was greater than 4.6 m [15 ft] (for example, a sample collected from 4.6 to 5.2 m [15 to 17 ft] would be considered a shallow-zone sample, while a sample collected from 4.9 to 5.2 m [16 to 17 ft] would be considered a deep-zone sample.

[d]In order to calculate the protection of groundwater soil cleanup level, conservative estimates of zero were assumed for both the Hcc and the Kd of this constituent.

[e]In order to calculate the protection of groundwater soil cleanup level, a conservative estimate of zero was assumed for the Kd of this constituent.

[f]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.

[g] Nitrate/Nitrite as N was not evaluated because the total nitrate and total nitrite concentrations have their own criterion.

[h]Maximum total nitrate and total nitrite results were converted to Nitrate as nitrogen (N) and Nitrite as N in order compare concentrations to cleanup levels calculated using toxicity values for nitrate as N and nitrite as N. Nitrate results were converted to nitrate as N with a factor of 0.225 and nitrite results were converted to nitrite as N with a factor of 0.304.

[i] Alternative Hcc and Kd values were used to calculate the cleanup level for this constituent. These alternative values are listed in Table F-4.

WAC = Washington State Administrative Code.
bgs = below ground surface.
COC = Contaminant of Concern.
GW = groundwater.
ND = included in analysis but not detected.
NLA = no laboratory analysis conducted.
TPH = total petroleum hydrocarbons.
-- = no cleanup level is available.
Shading indicates that the chemical was retained as a contaminant of concern.
Significant figures were considered when comparing values, but the most precise values are shown in the table.

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
216-A-29 Ditch					
Actinium-228[c]	1.32	0.429	2.7 [9.0] - 3.5 [11.5]	NLA	~
Americium-241	NA	145	1.2 [4.0] - 2.0 [6.5]	ND	~
Antimony-125	NA	1.67	1.2 [4.0] - 1.5 [5.0]	NLA	~
Barium-133	NA	ND	~	NLA	~
Bismuth-212[c]	NA	0.282	2.7 [9.0] - 3.5 [11.5]	NLA	~
Bismuth-214[c]	NA	0.392	2.7 [9.0] - 3.5 [11.5]	NLA	~
Carbon-14	NA	ND	~	NLA	~
Cerium-144[c]	NA	ND	~	NLA	~
Cesium-134	NA	ND	~	NLA	~
Cesium-137	1.05	98.4	1.2 [4.0] - 1.5 [5.0]	ND	~
Cobalt-60	0.00842	ND	~	ND	~
Curium-242[c]	NA	ND	~	NLA	~
Curium-243/244	NA	ND	~	NLA	~
Europium-152	NA	ND	~	ND	~
Europium-154	0.0334	ND	~	ND	~
Europium-155	0.0539	0.05	3.0 [10.0] - 0.0 [0.0]	ND	~
Lead-212[c]	NA	0.445	2.7 [9.0] - 3.5 [11.5]	NLA	~
Lead-214[c]	NA	0.432	2.7 [9.0] - 3.5 [11.5]	NLA	~
Neptunium-237	NA	0.124	3.5 [11.5] - 3.8 [12.5]	ND	~
Nickel-63	NA	ND	~	ND	~
Niobium-94	NA	ND	~	NLA	~
Plutonium-238	0.00378	15.7	1.2 [4.0] - 2.0 [6.5]	ND	~
Plutonium-239/240	0.0248	667	1.2 [4.0] - 2.0 [6.5]	ND	~
Potassium-40	16.6	16	1.8 [6.0] - 2.1 [7.0]	13.9	79.2 [260.0] - 79.9 [262.0]

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
Radium-226[d,f]	0.815	0.895	2.6 [8.5] - 2.9 [9.5]	0.514	79.2 [260.0] - 79.9 [262.0]
Radium-228[d]	1.32	1.11	1.8 [6.0] - 2.1 [7.0]	1.04	79.2 [260.0] - 79.9 [262.0]
Ruthenium-103[c]	NA	ND	~	NLA	~
Ruthenium-106	NA	ND	~	NLA	~
Sodium-22	NA	ND	~	NLA	~
Strontium-90[a]	0.178	0.779	3.0 [10.0] - 3.4 [11.0]	0.27	4.9 [16.0]
Technetium-99	NA	ND	~	ND	~
Thallium-208[c]	NA	0.136	2.7 [9.0] - 3.5 [11.5]	NLA	~
Thorium-228[d]	1.32	1.14	3.0 [10.0] - 3.4 [11.0]	0.948	30.5 [100.0] - 31.2 [102.5]
Thorium-230[d]	1.1	1.6	15.2 [50.0] - 16.0 [52.5]	1.6	15.2 [50.0] - 16.0 [52.5]
Thorium-232[d]	1.32	1.22	3.0 [10.0] - 3.4 [11.0]	1.07	45.7 [150] - 46.3 [152]
Thorium-234[c]	NA	ND	~	NLA	~
Tin-113[c]	NA	ND	~	NLA	~
Tin-126	NA	ND	~	NLA	~
Tritium	NA	7.05	79.2 [260.0] - 79.9 [262.0]	7.05	79.2 [260.0] - 79.9 [262.0]
Uranium-233/234[b]	1.1	2.31	2.3 [7.5] - 2.6 [8.5]	NLA	~
Uranium-234	1.1	0.964	3.0 [10.0] - 3.4 [11.0]	NLA	~
Uranium-235	0.109	0.439	1.2 [4.0] - 1.5 [5.0]	ND	~
Uranium-238	1.06	1.81	2.3 [7.5] - 2.6 [8.5]	ND	~
Zinc-65[c]	NA	ND	~	NLA	~
216-B-63 Trench					
Actinium-228[c]	1.32	0.44	5.3 [17.5] - 5.8 [19.0]	0.44	5.3 [17.5] - 5.8 [19.0]

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
Americium-241	NA	0.589	2.4 [8.0] - 3.2 [10.5]	0.0295	6.1 [20.0] - 6.9 [22.5]
Antimony-125	NA	ND	~	ND	~
Barium-133	NA	ND	~	NLA	~
Bismuth-212[c]	NA	0.276	5.3 [17.5] - 5.8 [19.0]	0.276	5.3 [17.5] - 5.8 [19.0]
Bismuth-214[c]	NA	0.311	5.3 [17.5] - 5.8 [19.0]	0.311	5.3 [17.5] - 5.8 [19.0]
Carbon-14	NA	ND	~	NLA	~
Cerium-144[c]	NA	ND	~	ND	~
Cesium-134	NA	ND	~	ND	~
Cesium-137	1.05	100	4.0 [13.0] - 4.7 [15.5]	ND	~
Cobalt-60	0.00842	ND	~	ND	~
Curium-242[c]	NA	ND	~	ND	~
Curium-243/244	NA	ND	~	NLA	~
Curium-244	NA	ND	~	ND	~
Europium-152	NA	ND	~	ND	~
Europium-154	0.0334	1.29	2.4 [8.0] - 3.2 [10.5]	ND	~
Europium-155	0.0539	ND	~	ND	~
Iodine-129	NA	ND	~	ND	~
Lead-212[c]	NA	0.443	5.3 [17.5] - 5.8 [19.0]	0.443	5.3 [17.5] - 5.8 [19.0]
Lead-214[c]	NA	0.362	5.3 [17.5] - 5.8 [19.0]	0.362	5.3 [17.5] - 5.8 [19.0]
Neptunium-237	NA	0.054	2.9 [9.5] - 3.2 [10.5]	ND	~
Nickel-63	NA	23	5.3 [17.5] - 5.8 [19.0]	23	5.3 [17.5] - 5.8 [19.0]
Niobium-94	NA	ND	~	ND	~
Plutonium-238	0.00378	0.081	5.3 [17.5] - 5.8 [19.0]	0.081	5.3 [17.5] - 5.8 [19.0]
Plutonium-239/240	0.0248	4.97	4.0 [13.0] - 4.7 [15.5]	0.026	5.3 [17.5] - 5.8 [19.0]
Plutonium-241	NA	ND	~	ND	~
Potassium-40	16.6	18.4	22.9 [75.0] - 23.6 [77.5]	18.4	22.9 [75.0] - 23.6 [77.5]
Radium-224[c]	NA	0.91	~	0.742	9.1 [30.0] - 9.9 [32.5]

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
Radium-226[d]	0.815	0.762	1.2 [4.0] - 2.0 [6.5]	0.67	76.7 [251.5] - 77.4 [254]
Radium-228[d]	1.32	0.917	1.2 [4.0] - 2.0 [6.5]	0.792	76.7 [251.5] - 77.4 [254]
Ruthenium-103[c]	NA	ND	~	ND	~
Ruthenium-106	NA	ND	~	ND	~
Selenium-79	NA	ND	~	ND	~
Sodium-22	NA	ND	~	NLA	~
Strontium-90[a]	0.178	4,710	4.0 [13.0] - 4.7 [15.5]	3.21	5.2 [17.0] - 5.5 [18.0]
Technetium-99[e]	NA	0.406	5.3 [17.5] - 5.8 [19.0]	0.406	5.3 [17.5] - 5.8 [19.0]
Thallium-208[c]	NA	0.14	5.3 [17.5] - 5.8 [19.0]	0.14	5.3 [17.5] - 5.8 [19.0]
Thorium-228[d, f]	1.32	1.47	30.5 [100.0] - 31.2 [102.5]	1.47	30.5 [100.0] - 31.2 [102.5]
Thorium-230[d]	1.1	2.67	2.4 [8.0] - 3.2 [10.5]	1.73	8.5 [28.0] - 9.1 [30.0]
Thorium-232[d]	1.32	1.03	30.5 [100.0] - 31.2 [102.5]	1.03	30.5 [100.0] - 31.2 [102.5]
Thorium-234[c]	NA	ND	~	ND	~
Tin-113[c]	NA	ND	~	ND	~
Tin-126	NA	ND	~	ND	~
Tritium	NA	0.33	5.2 [17.0] - 5.5 [18.0]	0.33	5.2 [17.0] - 5.5 [18.0]
Uranium-233/234[b]	1.1	0.36	1.5 [5.0] - 1.8 [6.0]	NLA	~
Uranium-234	1.1	0.748	2.3 [7.5] - 2.6 [8.5]	NLA	~
Uranium-235	0.109	ND	~	ND	~
Uranium-238	1.06	0.93	2.3 [7.5] - 2.6 [8.5]	0.653	76.7 [251.5] - 77.4 [254]
Zinc-65[c]	NA	ND	~	ND	~
216-S-10 Ditch					
Actinium-228[c]	1.32	0.51	7.6 [25.0] - 8.2 [27.0]	0.51	7.6 [25.0] - 8.2 [27.0]
Americium-241	NA	1.84	2.0 [6.5] - 2.7 [9.0]	ND	

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
Antimony-125	NA	ND	~	ND	~
Barium-133	NA	ND	~	NLA	~
Bismuth-212[c]	NA	0.321	7.6 [25.0] - 8.2 [27.0]	0.321	7.6 [25.0] - 8.2 [27.0]
Bismuth-214[c]	NA	0.426	7.6 [25.0] - 8.2 [27.0]	0.426	7.6 [25.0] - 8.2 [27.0]
Carbon-14	NA	ND	~	NLA	~
Cerium-144[c]	NA	ND	~	ND	~
Cesium-134	NA	ND	~	ND	~
Cesium-137	1.05	9.13	0.0 [0.0] - 0.5 [1.5]	ND	~
Cobalt-60	0.00842	ND	~	ND	~
Curium-242[c]	NA	ND	~	NLA	~
Curium-243/244	NA	ND	~	NLA	~
Europium-152	NA	ND	~	ND	~
Europium-154	0.0334	ND	~	ND	~
Europium-155	0.0539	ND	~	ND	~
Lead-212[c]	NA	0.498	7.6 [25.0] - 8.2 [27.0]	0.498	7.6 [25.0] - 8.2 [27.0]
Lead-214[c]	NA	0.39	7.6 [25.0] - 8.2 [27.0]	0.39	7.6 [25.0] - 8.2 [27.0]
Neptunium-237	NA	ND	~	ND	~
Nickel-63	NA	38.4	7.6 [25.0] - 8.2 [27.0]	38.4	7.6 [25.0] - 8.2 [27.0]
Niobium-94	NA	ND	~	ND	~
Plutonium-238	0.00378	ND	~	ND	~
Plutonium-239/240	0.0248	5.33	2.0 [6.5] - 2.7 [9.0]	0.021	7.6 [25.0] - 8.2 [27.0]
Potassium-40	16.6	14.3	41.1 [135.0] - 41.8 [137.0]	14.3	41.1 [135.0] - 41.8 [137.0]
Radium-226[d]	0.815	0.922	45.7 [150.0] - 46.3 [152.0]	0.922	45.7 [150.0] - 46.3 [152.0]
Radium-228[d]	1.32	1.1	45.7 [150.0] - 46.3 [152.0]	1.1	45.7 [150.0] - 46.3 [152.0]

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
Ruthenium-103[c]	NA	ND	~	ND	~
Ruthenium-106	NA	ND	~	ND	~
Sodium-22	NA	ND	~	NLA	~
Strontium-90[a]	0.178	0.462	0.9 [3.0] - 1.2 [4.0]	ND	~
Technetium-99	NA	ND	~	ND	~
Thallium-208[c]	NA	0.157	7.6 [25.0] - 8.2 [27.0]	0.157	7.6 [25.0] - 8.2 [27.0]
Thorium-228[d]	1.32	5.9	67.1 [220.0] - 67.7 [222.0]	5.9	67.1 [220.0] - 67.7 [222.0]
Thorium-230[d]	1.1	1.38	6.1 [20.0] - 6.7 [22.0]	1.38	6.1 [20.0] - 6.7 [22.0]
Thorium-232[d,f]	1.32	1.41	45.7 [150.0] - 46.3 [152.0]	1.41	45.7 [150.0] - 46.3 [152.0]
Thorium-234[c]	NA	0.591	7.6 [25.0] - 8.2 [27.0]	0.591	7.6 [25.0] - 8.2 [27.0]
Tin-113[c]	NA	ND	~	ND	~
Tin-126	NA	ND	~	ND	~
Tritium	NA	0.061	7.6 [25.0] - 8.2 [27.0]	0.061	7.6 [25.0] - 8.2 [27.0]
Uranium-234	1.1	0.524	2.6 [8.5] - 2.9 [9.5]	NLA	~
Uranium-235	0.109	ND	~	ND	~
Uranium-238	1.06	0.536	2.6 [8.5] - 2.9 [9.5]	ND	~
Zinc-65[c]	NA	ND	~	ND	~
216-S-10 Pond					
Americium-241	1.32	0.395	3.5 [11.5] - 3.8 [12.5]	ND	~
Antimony-125	NA	ND	~	NLA	~
Barium-133	NA	ND	~	NLA	~
Carbon-14	NA	12.2	2.0 [6.5] - 2.3 [7.5]	NLA	~
Cesium-134	NA	ND	~	NLA	~
Cesium-137	1.05	1.77	3.5 [11.5] - 3.8 [12.5]	0.336	5.2 [17.0] - 5.5 [18.0]

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
Cobalt-60	0.00842	ND	~	ND	~
Curium-242[c]	NA	ND	~	NLA	~
Curium-243/244	NA	ND	~	NLA	~
Europium-152	NA	ND	~	ND	~
Europium-154	0.0334	ND	~	ND	~
Europium-155	0.0539	ND	~	ND	~
Neptunium-237	NA	0.062	5.2 [17.0] - 5.5 [18.0]	0.062	5.2 [17.0] - 5.5 [18.0]
Nickel-63	NA	2.46	15.2 [50.0] - 15.8 [52.0]	2.46	15.2 [50.0] - 15.8 [52.0]
Plutonium-238	0.00378	ND	~	ND	~
Plutonium-239/240	0.0248	2.33	3.5 [11.5] - 3.8 [12.5]	0.317	5.2 [17.0] - 5.5 [18.0]
Potassium-40	16.6	13.9	60.2 [197.4] - 60.8 [199.4]	13.9	60.2 [197.4] - 60.8 [199.4]
Radium-226	0.815	0.739	4.9 [16.0] - 5.2 [17.0]	0.739	4.9 [16.0] - 5.2 [17.0]
Radium-228[d, f]	1.32	0.938	4.9 [16.0] - 5.2 [17.0]	0.938	4.9 [16.0] - 5.2 [17.0]
Sodium-22	NA	ND	~	NLA	~
Strontium-90[a]	0.178	1.57	15.2 [50.0] - 15.8 [52.0]	1.57	15.2 [50.0] - 15.8 [52.0]
Technetium-99	NA	ND	~	ND	~
Thorium-228[d, f]	1.32	1.45	3.7 [12.0] - 4.0 [13.0]	1.27	6.1 [20.0] - 6.4 [21.0]
Thorium-230[d,g]	1.1	1.59	4.1 [13.5] - 4.4 [14.5]	1.06	15.2 [50.0] - 15.8 [52.0]
Thorium-232[d]	1.32	0.938	4.9 [16.0] - 5.2 [17.0]	0.938	4.9 [16.0] - 5.2 [17.0]
Tin-126	NA	ND	~	NLA	~
Tritium	NA	1.53	4.9 [16.0] - 5.2 [17.0]	1.53	4.9 [16.0] - 5.2 [17.0]
Uranium-233/234[b]	1.1	0.577	6.1 [20.0] - 6.4 [21.0]	0.577	6.1 [20.0] - 6.4 [21.0]

Table 3-11. Groundwater Protection Pathway Background Comparison and Contaminants of Potential Concern for Radionuclides in Deep-Zone Soils (0 m to Groundwater and 4.6 m [15 ft] to Groundwater) for All Waste Sites. (8 sheets)

Constituent	Background (pCi/g)	Maximum Detected Concentration from 0 m to GW (pCi/g)	Depth of Maximum Detected from 0 m to GW [ft] bgs	Maximum Detected Concentration from 4.6 m to GW (pCi/g)	Depth of Maximum Detected from 4.6 m to GW [ft] bgs
Uranium-234	1.1	0.563	2.9 [9.5] - 3.2 [10.5]	NLA	~
Uranium-235	0.109	0.022	15.2 [50.0] - 15.8 [52.0]	0.022	15.2 [50.0] - 15.8 [52.0]
Uranium-238	1.06	0.568	2.9 [9.5] - 3.2 [10.5]	0.548	6.1 [20.0] - 6.4 [21.0]

[a]Analyzed as total beta radiostrontium.
[b]Uranium-233/234 evaluated as uranium-234.
[c]These radionuclides have a half-life of less than one year.
[d]Value based on assumption of secular equilibrium with the parent nuclide.
[e]Actual concentration may reside between 0.04 and 0.4 based on QC data.
[f]Additional background criteria were evaluated for this constituent. See Table 3-1 for a summary of these secondary background values.
[g] Site maximum concentration is lower than the lognormal 90th or 95th percentile or considered to not be significantly greater than background
GW = groundwater.
NA = not available or not analyzed.
ND = not detected.
NLA = no laboratory analysis conducted.
Shading indicates results were greater than background concentrations and are considered a COPC.

Table 3-12. Estimated Peak Radionuclide Groundwater Concentrations.

Groundwater Concentration for 216-A-29 Ditch Head End				
		Peak Concentration		
Upper Layer	**Nuclide**	**Activity**	**Mass**	**EPA MCL**
	na	na	na	na
Lower Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Tritium	1,300	20 y	20,000 pCi/L
Groundwater Concentration for 216-A-29 Ditch Outlet End				
		Peak Concentration		
Upper Layer	**Nuclide**	**Activity**	**Mass**	**EPA MCL**
	Uranium-234	483 pCi/L	0.078 µg/L	
	Uranium-238	380 pCi/L	1,129 µg/L	
		Total U:	**1,129 µg/L**	**30 µg/L**
Peak Uranium Concentration is at 5,174 y				
	Nuclide	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Neptunium-237	na	na	na
Lower Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Tritium	2,800	20 y	20,000 pCi/L
Groundwater Concentration for 216-B-63 Trench				
Upper Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Technitium-99	185	2,273 y	900 pCi/L
Lower Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Nickel-63	na	na	na
Groundwater Concentration for 216-S-10 Ditch				
Upper Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	na	na	na	na
Lower Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Nickel-63	na	na	na
Groundwater Concentration for 216-S-10 Pond				
Upper Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Carbon-14	8,260	1,323	2,000 pCi/L
Lower Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Nickel-63 & Strontium-90	na	na	na
Bottom Layer	**Nuclide**	**Peak pCi/L**	**Peak Year**	**EPA MCL**
	Plutonium-239	na	na	na
"na" means the contaminants did not reach groundwater within 10,000 y.				

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Table 3-13a. Summary of Locations and Depths with Ecological Soil Indicator Value or Groundwater Protection Value Exceedances at the 216A-29 Ditch.

	AD-1		B8826		AD-3		Area 9		Area 8		AD-2	
Depth (m [ft] bgs)	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**
0.9 [3]									Selenium (1.7x)			
1.2 [4]							Selenium (1.6x)					
1.2 [4]–1.5 [5]	Aroclor-1254 (2.9x); Cadmium (2x); Selenium (3.3x); Silver (10x); Dibutyl phthalate (1.3x); Cesium-137 (4.9x); Bis (2-ethylhexyl) phthalate (7.3x)	Cadmium (28x) Mercury (2.5x); Silver (3.1x); Nitrate (1.2x); 1,2-Dichloroethane (5.6x); Aroclor-1254 (7.2x); Benzo(a)anthracene (2.1x); Chrysene (2.2x); Methylene chloride[a] (3.6x); Sulfate (3.0x); Tetrachloroethylene (6.9x)										
1.5 [5]-1.8 [6]											Arsenic (1.1x)	Arsenic (1.2x)
1.2[4]-2.0 [6.5]				Aroclor-1254 (1.9x); Mercury (2.1x); Cadmium (5.3x); Tributyl phosphate (17x)								
2.0 [6.5]-2.3 [7.5]	Arsenic (1.2x)	Arsenic (1.3x)										
1.8 [6]-2.1 [7]					Arsenic (1.7x); Thallium (3.3x)	Arsenic (1.9x)						
2.1 [7]							Selenium (1.5x)					
2.3 [7.5]-2.6 [8.5]											Lead (3.3x); Selenium (1.8X); Silver (1.6x); Vanadium (1.2x)	Cadmium (2.3x); Mercury (2.1x); Total Uranium (1.6x); Methylene chloride[a] (1.1x); Uranium-233/234 (2.1x); Uranium-238 (1.7x)
2.6 [8.5]-2.9 [9.5]					Arsenic (1.7x)	Arsenic (1.9x)						
2.7 [9]-3.0 [10]	Arsenic (1.3x); Selenium (1.6x)	Arsenic (1.4x)										
2.7 [9]-3.5 [11.5]			Selenium (8.4x)	Cadmium (3.7x)								
3.0 [10]							Selenium (2x)		Selenium (2.3x)			
4.0 [13]										Cadmium (2.2x)		
4.9 [16]												
79.2 [260] – 79.9 [262]				Methylene chloride (1.7x)								
82.9 [272] – 83.5 [274]												

[a] Methylene chloride is qualified "B" due to the associated lab blank contaminated with the chemical. No other non-qualified, detected values were greater than the WAC cleanup level.

Table 3-13b. Summary of Locations and Depths with Ecological Screening Value or Groundwater Protection Value Exceedances at the 216-B-63 Trench.

	E33-333		B8827		BT-1		BT-2	
Depth (m [ft] bgs)	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**
1.2 [4]-2.0 [6.5]	Antimony (19x); Selenium (1.5x)							
1.5 [5]-1.8 [6]								Benzene (1.8x); Nitrate (1.1x)
1.8 [6]-2.1 [7]							Thallium (3.3x); Strontium-90 (1.2x)	
2.1 [7]-2.4 [8]					Selenium (1.3x)			
2.3 [7.5]-2.6 [8.5]							Selenium (2.5x); Strontium-90 (1.5x)	
2.9 [9.5]-3.2 [10.5]						Methylene chloride (1.2x)[a]		
2.4 [8]-3.2 [10.5]	Selenium (1.1x); Aroclor-1260 (14x); Cesium-137 (3.6x); Strontium-90 (189x)	Aroclor-1260 (12.8x)						
3.2 [10.5]-4.0 [13]	Selenium (1.5x); Strontium-90 (4.3x)		Selenium (1.4x)					
4.0 [13]-4.7 [15.5]	Aroclor-1260 (1.7x); Cesium-137 (5x); Strontium-90 (236x)	Aroclor-1260 (1.5x)						
5.3 [17.5]-5.8 [19]				Cadmium (2.4x)				

[a] Methylene chloride is qualified "B" due to the associated lab blank contaminated with the chemical. No other non-qualified, detected values were greater than the WAC cleanup level.

[b] Results for E33-333 are included in this table for informational purposes. E33-333 is not located within the 200-CS-1 OU and is not being considered in the remediation options described in this FS.

Table 3-13c. Summary of Locations and Depths with Ecological Screening Value or Groundwater Protection Value Exceedances at the 216-S-10 Ditch.

Depth (m [ft] bgs)	SD-2		SD-3		W26-14		SD-1	
	SLERA	Groundwater Protection Pathway	SLERA	Groundwater Protection Pathway	SLERA	Groundwater Protection Pathway	SLERA	Groundwater Protection Pathway
0.0 [0]-0.46 [1.5]	Chromium-Total (12x); Copper (1.1x); Silver (7.2x); Thallium (3.7x); Zinc (1.4x); Aroclor-1254 (1.1x); Dibutyl phthalate (1.1x)	Mercury (2.1x); Silver (2.2x); Aroclor-1254 (2.8x); Benzo(a)anthracene (6.4x); Benzo(a)pyrene (2.6x); Benzo(b)fluoranthene (1.8x); Benzo(k)fluoranthene (1.6x); Chrysene (7.1x)						
0.46 [1.5]-0.91 [3]	Chromium-Total (4.3x); Silver (6.8x)	Silver (2.1x)						
0.91 [3]-1.2 [4]			Thallium (6.2x)					
1.8 [6]-2.1 [7]							Thallium (4.3x)	
2.6 [8.5]-2.9 [9.5]							Selenium (1.5x)	
7.62 [25]-8.22 [27]						Cadmium (2.3x)[a]		
41.1 [135]-41.8 [137]								
45.7 [150]-46.3 [152]								
67.1 [220]-67.7 [222]								

[a] This cadmium concentration is the higher of a pair. The other result from this sample location and depth was analyzed at a different laboratory and was below detection limits.
Note: no samples were collected below 3' at sample location SD-2.

Table 3-13d. Summary of Locations and Depths with Ecological Screening Value or Groundwater Protection Value Exceedances at the 216-S-10 Pond.

Depth (m [ft] bgs)	SP-1		SP-2		SP-3		SP-4		W26-13	
	SLERA	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**
1.2 [4]-1.5 [5]							Thallium (3.9x)			
2.0 [6.5]-2.3 [7.5]				Carbon-14 (4.1x)[a]						
2.1 [7]-2.4 [8]										
2.4 [8]-2.7 [9]							Selenium (1.5x)			
2.7 [9]-3.0 [10]			Silver (2x)							
2.9 [9.5]-3.2 [10.5]										
3.4 [11]-3.7 [12]										
3.5 [11.5]-3.8 [12.5]										
4.9 [16]-5.2 [17]						Methylene Chloride (1.1x)				
5.2 [17]-5.5 [18]										
6.1 [20]-6.4 [21]										
60.0 [197]-60.7 [199]										

[a] Only the topmost depth was analyzed for C-14 at each test pit (not the borehole) (i.e., a total of 4 samples, 1 from each test pit). The other samples were below detection limits.

Table 3-14. Summary of Risk Drivers.

	216-A-29 Ditch		**216-S-10 Ditch**		**216-B-29 Ditch**		**216-S-10 Pond**	
Depth (m [ft] bgs)	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**	**SLERA**	**Groundwater Protection Pathway**
0.0 [0]-0.46 [1.5]	ND	ND	Chromium-Total (12x); Silver (7.2x)	Aroclor-1254 (2.8x); Benzo(a)anthracene (6.4x); Benzo(a)pyrene (2.6x); Benzo(b)fluoranthene (1.8x); Benzo(k)fluoranthene (1.6x); Chrysene (7.1x)	ND	ND	ND	ND
0.46 [1.5]-0.91 [3]	ND	ND	Chromium-Total (4.3x); Silver (6.8x)	ND	ND	ND	ND	ND
1.2 [4]–1.5 [5]	Aroclor-1254 (2.9x); Silver (10x); Cesium-137 (4.9x); Bis (2-ethylhexyl) phthalate (7.3x)	Cadmium (28x); 1,2-Dichloroethane (5.6x); Aroclor-1254 (7.2x); Benzo(a)anthracene (2.1x); Chrysene (2.2x); Tetrachloroethylene (6.9x);	ND	ND	ND	ND	ND	ND
1.2[4]-2.0 [6.5]	ND	Aroclor-1254 (1.9x); Cadmium (5.3x); Tributyl phosphate (17x)	ND	ND	ND	ND	ND	ND

ND = no risk drivers are identified at the depth